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Report 85-1

Compiled and Edited by
K. Brewer, D. Walsh and R.V. Gibbons

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Mineral Development Division
Department of Mines and Energy
Government of Newfoundland and Labrador

CURRENT RESEARCH

Report 85-1

Compiled and Edited by
K. Brewer, D. Walsh and R.V. Gibbons

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PREFACE

This publication is the twelfth in the Mineral Development Division's annual Report of Activities series.

During the past year the Division continued its field program in geological mapping, geochemical surveys, and mineral deposit assessment, and added new projects in paleontology, drift prospecting, and metallogeny of Labrador granites. Highlights of the field program include the completion of 1:50,000 scale mapping along the south coast of Newfoundland, the discovery of exciting new gold potential in Labrador and on the island, and the preliminary documentation of large reserves of silica and dolomite in western Labrador.

Many of the Division's field programs this past year were funded under the new Canada-Newfoundland Subisidiary Agreement on Mineral Development (1984-1989), which was signed in May. The Agreement provides for the expenditure of some 22 million dollars over the next five years on geoscience, mining and minerals technology, and mineral economics. Projects carried out under the Agreement are identified as such in this report.

B.A. Greene, Director
Mineral Development Division

Any reader who would like to write a rebuttal to, or discussion of, any report contained in this volume is invited to submit it to the editor by November 1, 1985, to be considered for inclusion in Report 86-1.

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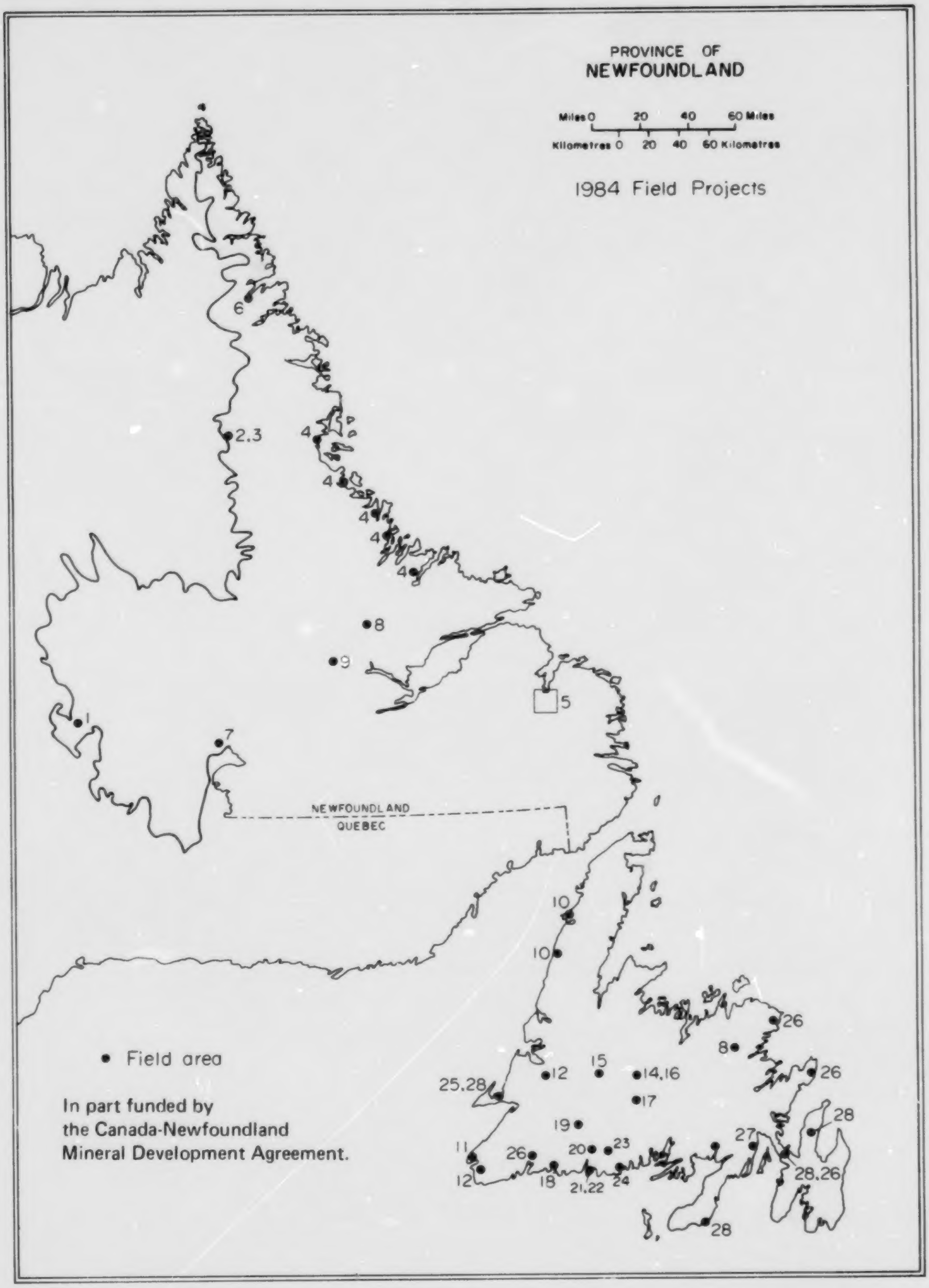
PROVINCE OF
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Miles 0 20 40 60 Miles
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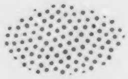
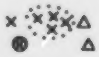
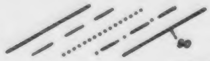
Field area
In part funded by
the Canada-Newfoundland
Mineral Development Agreement.

LIST OF SYMBOLS USED ON GEOLOGICAL MAPS AND FIGURES

Drift covered area


Rock outcrop, area of outcrop, probable outcrop, float, frost-heaved rock


Geological boundary (defined, approximate, assumed, gradational, dip indicated)


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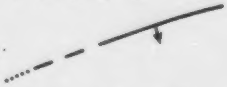
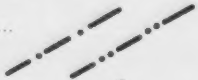
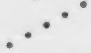
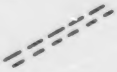
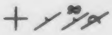
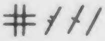


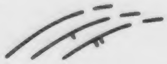
Unconformity (defined, assumed)


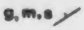
Limit of geological mapping


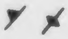
Limit of area surveyed with aircraft


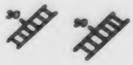
Bedding, tops known (horizontal, inclined, vertical, overturned)


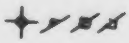
Bedding, tops unknown (horizontal, inclined, vertical, dip unknown)


Bedding, general trend (dip unknown, top unknown; dip and top known; dip known, top unknown)


Bedding, estimated dip (gentle, moderate, steep)


Igneous flow banding (inclined, vertical)


Igneous intrusive sheets (inclined, vertical)


Primary igneous layering, tops known (horizontal, inclined, vertical, overturned)


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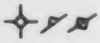
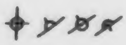
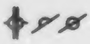
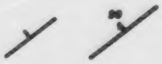
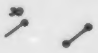
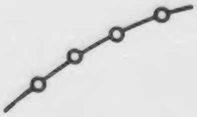
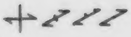
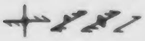
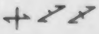
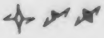
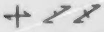
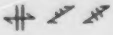
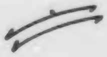
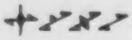
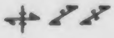
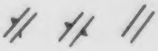
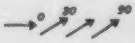


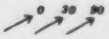
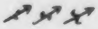
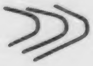
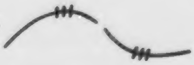
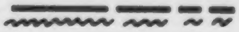
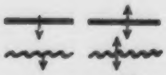
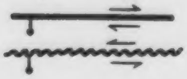
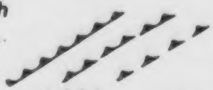
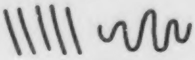
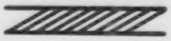
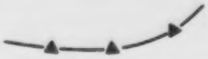
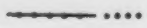
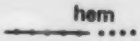
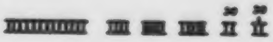
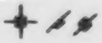
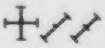
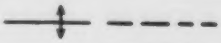
Strike and dip of pillows, tops known (horizontal, inclined, vertical, overturned)


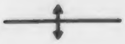
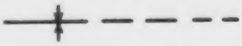
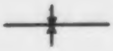
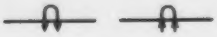
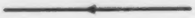
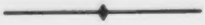
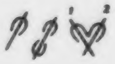
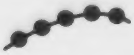
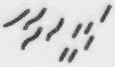
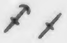
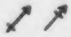
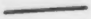
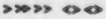
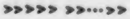
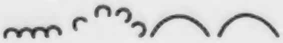
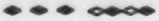
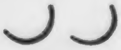
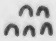
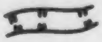
Strike and dip of pillows, tops unknown (horizontal, inclined, vertical)


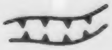
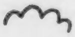
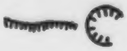
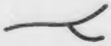
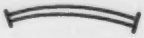
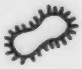
Primary igneous mineral lamination (inclined, vertical)


Primary igneous mineral lineation (inclined, vertical)


Flow Contact	
Zone containing xenoliths	△
Zone of intrusive agmatite	▲
Roof pendant (unit number indicated; too small to map separately)	△
Zone containing autoliths	▽
Breccia of various origins	▼
Slaty cleavage (horizontal, inclined, vertical, dip unknown)	
Strain-slip cleavage (horizontal, inclined, vertical, dip unknown)	
Schistosity, cleavage, foliation; used where ages of foliation are indicated on the map (horizontal, inclined, vertical)	
Schistosity of unknown age	
S_1	
S_2	
Schistosity, gneissosity, cleavage, foliation, general trend	
Gneissic foliation (horizontal, inclined, vertical, dip unknown)	
Gneissic banding (horizontal, inclined, vertical)	
Axial plane of minor fold (inclined, vertical, dip unknown)	
Lineation (horizontal, inclined, inclined but plunge unknown, vertical)	
Type of lineation denoted by letter:	
Mineral lineation	M→
S intersections	S→
Microcrenulations	C→
Buudin axes	B→
Deformed clasts	D→
Igneous inclusions	I→
Rodding, mullion structure	R→
Metamorphic aggregates	A→
Deformed pillows	P→

Age of lineation and of minor fold axes	
Lineation of unknown age	
L_1	
L_2	
Axes of minor folds (horizontal, inclined, vertical)	
Sense of vergence of minor structures (used with minor fold axes symbol or lineation S intersection symbol; read looking along the arrow)	
Structural trend (from aerial photographs)	
Lineament (from aerial photographs)	
Fault (defined, approximate, assumed)	
Fault (inclined, vertical)	
Fault (solid circle indicates downthrown side, arrows indicate relative movement)	
Thrust fault (teeth in direction of dip; defined, approximate, assumed) (teeth indicate upthrust side)	
Zone of numerous imbricate thrust faults	
Fault zone, shear zone (width indicated)	
Tectonic slide	
Vein fault (defined, assumed)	
Mineralized bed or seam (hematite)	
Dike, vein, or stockwork (defined, approximate, assumed; unit number and dip indicated)	
Joint (horizontal, inclined, vertical)	
Sheeted dikes (horizontal, inclined, vertical)	
Anticline (defined, approximate, assumed)	

Antiform	
Syncline (defined, approximate, assumed)	
Synform	
Anticline and syncline (overturned)	
Anticline or syncline (arrow indicates plunge)	
Antiform or synform	
Glacial striae (direction of ice movement known, unknown). Numbers indicate relative age, 1 being the oldest	
End moraine	
Minor moraines, rib moraines, washboard moraines, "annual" moraines, till ridges transverse to ice flow (irregular, straight)	
Drumlins, drumlinoid ridges (direction of ice movement known, unknown)	
Crag and tail hills and ramps	
Glacial linear feature	
Pingo or palsen	
Esker (direction of flow known, unknown)	
Esker (continuous, discontinuous)	
Raised beaches	
Limit of marine or lacustrine submergence (well marked, assumed)	
Dunes	
Area of sand dunes	
Buried valley	

Abandoned river channel, spillway, ice-marginal channels, rill patterns, etc.	
Landslide scar	
Escarpment and cirques	
Fossil locality	Ⓕ
Locality where age has been determined, in millions of years	Ⓐ 180
Ice divide	— — —
Land system boundary	
Location of measured section	
Gravel pit or quarry (active, abandoned)	× X̲
Borrow pit (active, abandoned)	X̄ X̲̄
Rock dump or tailings	
Rock quarry (active, abandoned)	⚒̲
Mine (lead, zinc)	⚒ Pb, Zn
Mine (lead, zine; abandoned)	⚒̲ Pb, Zn
Mineral prospect; mineral occurrence (manganese)	×● × Mn
Placer deposit (gold)	× Au
Show of oil and gas (abandoned)	✷
Show of gas(abandoned)	☼
Gas producer	○
Oil producer	✹
Oil and gas producer	●

Location of drilling	○
Dry (abandoned)	⌖
Water source or disposal	⚲
Shearing and dip	⟋
Salt spring	ss ○~
Hot spring	hs ○~
Mineral isograd	-■-■-■-■-■-
Other alternatives when more than one	-□- -○- -●- △ ★
Shaft, raise, winze	◘ ■ ⊠
Shaft (abandoned)	◙
Trench	≍
Open cut; axial	∩
Adit or tunnel	≻— ≻=
Adit or tunnel (caved)	≻⌿ ≻≠
Borehole	●BH ●BH 3
Diamond drill hole	● DDH
(Surface projection of geology inferred)	–○
Sinkhole	○ SH
Gossan	G G ▨
Trace of coal seam	—— ——

ADDITIONAL SYMBOLS

Geological boundary (geophysically defined)	⋰
Geophysical conductor	-•-•-
Roche moutonnee	↗
Meltwater channel	- - -→
Sinkhole	**SH**
Open pit, mine or quarry	⬭
Locality where age has been determined, in thousands of years before the present	Ⓕ$^{12.5}$
Till fabric (direction known, unknown, known plus cross fabric)	↗ ⤢ ↗

SAMPLE LOCALITIES (SURFICIAL)

Glacial till	●	*Clay*	+
Gravel	⊖	*Organic*	✸
Sand	○	*Rock*	Ⓡ
Silt	■	*Pleistocene fossil*	Ⓕ

INDUSTRIAL MINERALS IN LABRADOR WEST

by

P.L. Dean and J.R. Meyer
Mineral Deposits Section

An industrial mineral survey was carried out in the Wabush/Labrador City area of western Labrador during the 1984 field season. The aim was to evaluate the potential of quartzites as a source of silica and dolomitic marbles for industrial filler and possible use in the pelletization of iron ore concentrate. The best exposures of both commodities were chip sampled and described to determine their purity, consistency, structure, size, and accessibility.

The Wishart quartzite and Denault marble are two formations of the Aphebian Knob Lake Group within the Labrador Trough. Sediments of the Knob Lake Group were deposited in a miogeosyncline at the eastern edge of the Superior craton. The Denault Formation is predominantly a dolomitic marble unit thought to have been deposited as shelf carbonates (Zajac, 1974), and the Wishart quartzites are thought to have been a littoral facies both overlying and forming a western equivalent to the Denault Formation (Rivers, 1983). Both formations are overlain by the Sokomon Formation which contains the rich banded iron formations of western Labrador.

In this southernmost extension of the Labrador Trough, the sediments are metamorphosed and deformed to a much higher degree than equivalent sediments to the north. Rivers (1983) has described three generations of Grenvillian folding, two of which form a strong structural interference pattern in the quartzites, resulting in dome structures which present good potential quarry sites.

MARBLE DEPOSITS

The Denault Formation is a dolomitic to calcitic and siliceous marble unit that underlies much of the area along the east side of Wabush Lake and a large area to the south of the lake. It is commonly massive in appearance and may contain quartz as isolated inclusions, stringers, lenses and/or beds. These have been identified as chert nodules, lenses, and conformable beds in unmetamorphosed equivalent rocks to the north. The formation is generally recessive and most chip samples were obtained from low outcrops along roads that cut through the formation. In the Duley Lake and Elephant Head Lake areas, exposures are more resistant and ridge-forming due to the presence of calc-silicate interbeds. These areas have little potential because of these impurities.

There are two prospects which are considered to have good potential for high quality dolomitic marble (Figure 1). The most promising prospect is 7 km east of Labrador City near the southern end of the Javelin Road. The exposure is flat-lying, 20 m by 25 m in size, and rises slightly above the surrounding area. On a fresh surface, the marble is white, coarsely crystalline (2.5 mm in diameter), with a very uniform texture and a bright vitreous appearance. There are no quartz or tremolite bands visible across the entire outcrop. A 15 kg sample was obtained from this prospect by using a portable rock saw to make three sets of parallel cuts 3-6 cm deep and spaced 4-5 cm apart over a strike length of 1.5 to 2.0 metres. The surface weathering was chiselled off first, and the marble being very brittle, was easily chipped out of the channels. This prospect is in the middle of a synform (approximately 1.5 km wide) which tapers to the southeast and widens to the northwest. It is adjacent to a road and is very accessible for drilling if the preliminary analyses are encouraging.

The second prospect is 700 m north of Leila Wynne Lake. The exposure is excellent, outlining an area at least 150 m wide which rises 5-10 m above the bog to the south, and extends a minimum of 500 m to the north. The marble is equigranular (1.5 mm crystals), flesh pink to light yellow in color on fresh surfaces, and occasionally stained a deep red with rust coated fractures. Two channel samples of 15-20 kg, each representing over 5 m in strike length, were obtained at this location. The marble does not break away from this outcrop in a brittle fashion. This may reflect the impurities, which include 3-5% pink to light yellow tremolite in 1-4 cm long fibrous crystals, and traces of chalcocite, malachite, and pyrite. There is no quartz visible in either channel sample; however resistant quartz veins, up to 1 cm thick, are present in the area between the two samples. There are bands of tremolite which also stand out on weathered surfaces as widely spaced, slightly resistant 2-5 mm wide parallel ridges. These generally trend northeast and may represent original bedding. This site is also accessible for drilling, being only 750 m from a winter road that trends southeast off the north end of the Javelin Road.

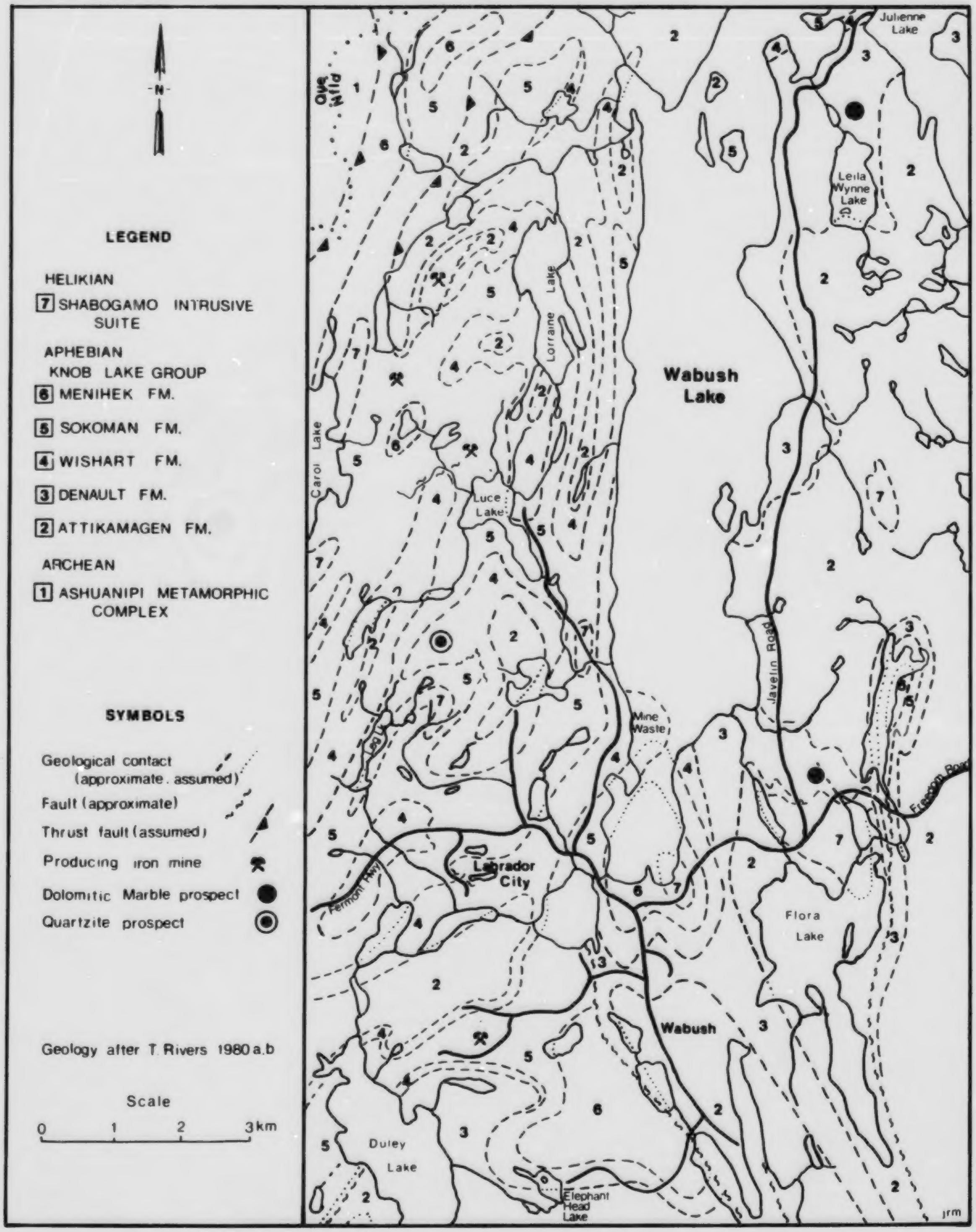


Figure 1: *Geological map of Labrador City/Wabush area.*

SILICA DEPOSITS

The Wishart Quartzite is a prominent physiographic unit exposed on the west side of Wabush Lake. The white quartzite ridges north and west of Labrador City are particularly clean and represent significant reserves of high quality silica. Most of the larger ridges are within 5 km of the town of Labrador City and several are adjacent to existing iron ore mining operations.

The quartzite ridges vary in size from 100 m long by 10 m wide to 3000 m long by 700 m wide and some have more than 100 m of vertical relief. Many ridges are adjacent to iron oxide deposits since the Wishart Formation generally underlies the iron bearing Sokomon Formation in the Wabush Lake area.

The quartzites occur as four distinct types. (1) Massive white recrystallized quartzite forms the largest and most prominent ridges. It is remarkably free of impurities and shatters when broken by a hammer. Outcrops are generally brilliant white, often glacially polished, and may contain local, narrow diffuse light brown to pink zones. (2) Granular quartzite is generally white to gray and has a distinct rough, granular weathered surface. Ridges dominated by this type often contain zones of massive whiter quartzite and narrow bands of micaceous quartzite may also occur. (3) Micaceous quartzite occurs in bands generally less than 1 m thick and contains up to 10% muscovite, chlorite, biotite and other silicates. These minerals may represent original muddy layers within the quartzites. (4) White friable quartzite occurs only in one area on the north side of the Fermont highway, 1.5 km west of Labrador City. This unique exposure is so friable that it may be sampled with an ordinary shovel and can be considered to be a silica sand deposit.

The sample program was carried out by collecting chip samples from sections that were measured perpendicular to the strike of the best exposed ridges. The sections were divided into 7-10 m intervals and rock chips were collected every 0.5 to 1 m. There are 383 samples presently undergoing major element analysis, and they represent 33 sections of 25 to 500 m in length. Evaluation of the quartzite ridges will be based on these analyses, field descriptions and accessibility.

The best of many excellent prospects, is a well rounded hill of white massive quartzite which is approximately 750 m in diameter with a minimum of 100 m relief. It is 4 km south of the Iron Ore Company of Canada's Smallwood pit, and within 1 km of existing roads (Figure 1). It is visually the most pure exposure of quartzite and its structure and relief offer excellent quarry potential. This single exposure represents approximately 200 million tonnes of relatively pure silica.

ACKNOWLEDGEMENTS

Angela Best and Dianne Andrews are thanked for all their rock chipping, aerobic exercise classes, and pharmaceutical advice. W. Tuttle provided quick delivery of supplies from Goose Bay and Iron Ore Company of Canada is thanked for access to their roads and property.

The manuscript was reviewed by Jim Butler.

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QUATERNARY MAPPING AND DRIFT EXPLORATION IN THE STRANGE LAKE AREA, LABRADOR

by

M.J. Batterson, D.M. Taylor and S.V. Vatcher[1]
Quaternary Geology Section

ABSTRACT

Situated approximately 145 km west of Nain, the recently discovered Zr-Nb-Ta-Be-REE Strange Lake deposit has provided a rare opportunity for studying the patterns of glacial dispersal, both geochemical and lithological, from a deposit of known extent. The area was affected by a continental glacial regime advancing towards 070. The sampling program in 1984 was designed to supplement and enhance the lake and stream waters and sediment plus reconnaissance till sampling undertaken in 1983. The current project focused on systematic sampling of tills across map sheets 14D/5 and 24A/8 with the aim of characterizing the geochemical signature of the deposit. Further, lithologic analyses of both intra-till clasts and surface boulders were also undertaken. Data analyses are still in preliminary stages, but suggest a well defined dispersal train with Be and Pb being particularly good indicators. Similarly, lithological analyses suggest the boulder train may reflect geological differentiations related to specific parts of the deposit.

INTRODUCTION

The recent discovery of a Zr-Nb-Ta-Be-REE deposit by the Iron Ore Company of Canada at Strange Lake has generated considerable interest, both in terms of its economic potential and in terms of characterising geochemical dispersal trains. From the Quaternary viewpoint, the discovery offers an excellent opportunity to study the effects of dispersal from a deposit of known (or almost known) extent affected by a continental glacial regime. Indeed, detailed till geochemistry has been completed by R. Dilabio of the Geological Survey of Canada. Further, analysis and discernment of the geochemical signature from the mineralisation may be applied to other areas where the origin of geochemical anomalies or mineralised boulders is unknown.

REGIONAL SETTING

The Strange Lake deposit is situated approximately 145 km west of Nain, on the Labrador-Quebec border. The study area comprised N.T.S. map sheets 14D/5 and the Labrador portion of 24A/8, a total area of approximately 1010 km^2.

The study area has been included in several small-scale terrain classification programmes (Lopoukhine et al., 1977; Douglas and Drummond, 1955). Both have characterized the area as 'high plateau', although this may be refined to one of a 'dissected upland'. The area is a peneplain surface which was elevated above sea level during the Pliocene (Cooke, 1929). This surface has been named the Nain plateau (Ives, 1960), and attains a maximum elevation of 700 m above sea level near the coast, decreasing inland to around 550 m above sea level in the study area. Climatically, the Strange Lake area falls within the zone of discontinuous permafrost.

GLACIAL HISTORY

Evidence from numerous sources, both terrestrial and marine, suggests a complex series of glaciations during the Quaternary for most of northeastern North America. However, the Strange Lake area reveals evidence of only the Late Wisconsin glaciation, the last major phase of glacial activity in northern Labrador.

Little is understood of the development of the Laurentide ice sheet, although Ives (1957) postulates that climatic deterioration led to 'instantaneous glacierization' of the high plateau areas. Subsequent ice flow patterns relate to an ice centre to the east of Hudson Bay (Shilts, 1980; Dyke et al., 1982 and others). Flow was not topographically controlled.

Deglaciation was probably by downwasting rather than a recessional process (Ives, 1960). The lack of recessional moraines and the widespread presence of glaciofluvial features and deposits both in the field area and elsewhere may be cited as supporting evidence. Deglaciation probably started about 10,500 years B.P. (Short, 1978) around the coast, with the Strange Lake area probably becoming ice free sometime after 9000 years B.P. (Short, 1978; Ives et al., 1976). A major pro-

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This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

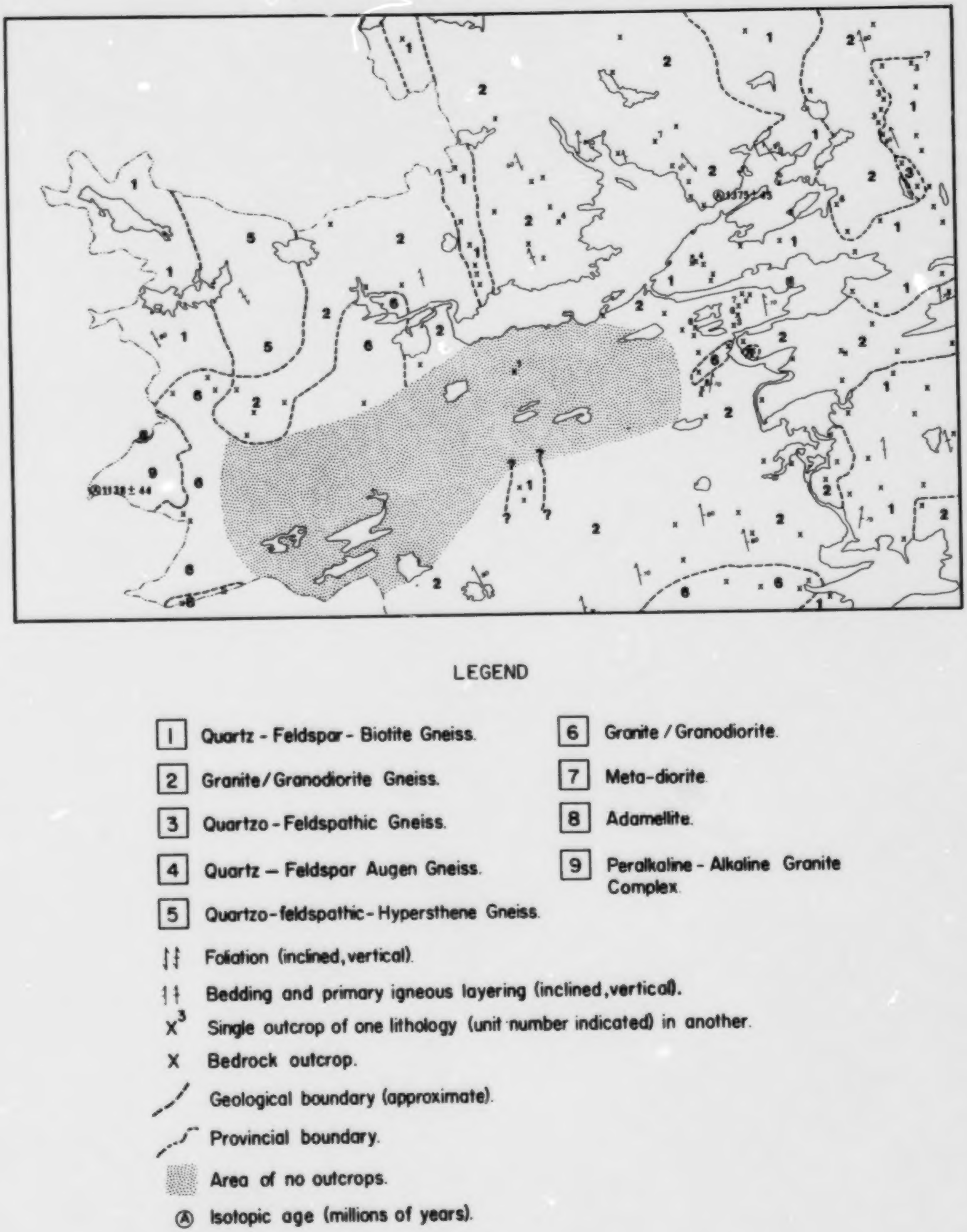
LEGEND
1 Quartz - Feldspar - Biotite Gneiss.
2 Granite/Granodiorite Gneiss.
3 Quartzo - Feldspathic Gneiss.
4 Quartz – Feldspar Augen Gneiss.
5 Quartzo-feldspathic - Hypersthene Gneiss.
6 Granite / Granodiorite.
7 Meta-diorite.
8 Adamellite.
9 Peralkaline - Alkaline Granite Complex.
Foliation (inclined, vertical).
Bedding and primary igneous layering (inclined, vertical).
X³ Single outcrop of one lithology (unit number indicated) in another.
X Bedrock outcrop.
Geological boundary (approximate).
Provincial boundary.
Area of no outcrops.
Ⓐ Isotopic age (millions of years).

Figure 1: *Geological map of the Strange Lake area.*

glacial lake developed to the west of the study area, between ice inland and the highlands to the east. Glacial Lake Naskaupi existed for about 1000 years, until final retreat of the inland ice led to its decline. A major outflow channel was through the Kogaluk River system (Barnett and Peterson, 1964), 20 km to the south of Strange Lake. The study area was probably unaffected by major drainage from Lake Naskaupi.

GEOLOGY

Apart from the alkaline-peralkaline granite complex that hosts the Strange Lake mineral deposit, the area has only been the focus of reconnaissance level geological mapping (Taylor, 1970, 1979), which has characterized it as comprising Aphebian migmatites and associated lithologies, intruded by younger Paleohelikian adamellitic rocks in the central-eastern part. Subsequent bedrock mapping has redefined the intrusive body as housing the Strange Lake complex (see Miller, this volume), and an attempt has been made to subdivide the migmatitic group into discrete units, the latter as part of the 1984 Quaternary mapping project. On this basis, a compilation map has been produced (Figure 1). Clearly, however, more detailed bedrock mapping is required. The Strange Lake deposit occurs within a suite of peralkaline granites, which are composed of K-feldspar, quartz, albite and riebeckite with or without aegirine, together with accessory zircon, gittinsite, fluorite, hematite, pyrochlore and allanite (Hlava and Krishnan, 1980).

TERRAIN ANALYSIS

A detailed aerial photograph interpretation of the Strange Lake area was undertaken before the field season. Subsequent fieldwork resulted in a refinement of the initial picture, a compilation of which is presented (Figure 2). In general terms, four major terrain units are identifiable. The most widespread unit can be described as till, which covers approximately 45% of the field area. The till ranges from a veneer (<1 m) in areas of high relief to extensive thicknesses (>10 m) in subdued relief areas. In many cases, the till has a lineated appearance, reflecting regional glacial movements. Within the lowlands, along well defined paleo-valleys, glaciofluvial terrain is exposed. This covers 30%

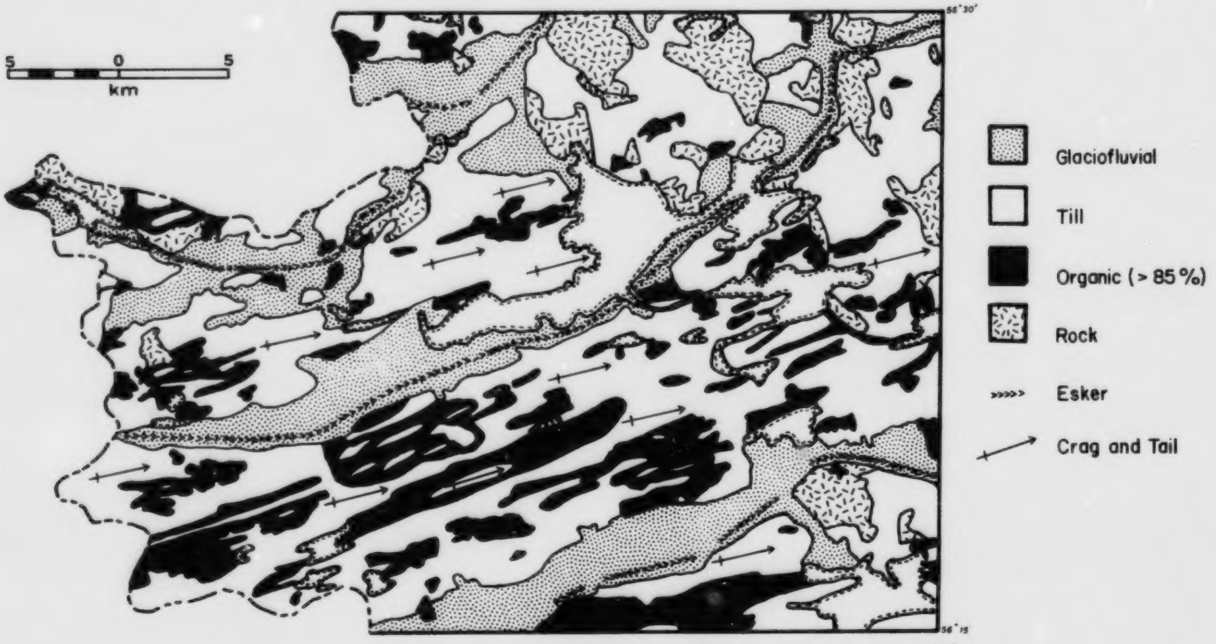

Figure 2: *Surficial terrain map of the Strange Lake area.*

of the area and is either exposed as a veneer of well-sorted sand or gravel overlying till, or as a distinct esker ridge, the latter reflecting subglacial drainage channels. Areas of subdued relief within the till terrain are often the site of poor postglacial drainage, reflected by organics (15% of area), which often are a veneer (<1 m). The final major terrain unit is bedrock (10% of area). These areas are most often found in the uplands, but are also exposed as discrete crags across the map area or within the outwash channels.

SAMPLING PROGRAM

Detailed sampling of lake and stream waters and sediments was undertaken as part of a field study in 1983 (McConnell et al., 1984). In association with this, a reconnaissance level till sampling program was completed. Detailed till sampling was also undertaken in the vicinity of the deposit by R. Dilabio of the Geological Survey of Canada. The 1984 project was designed to enhance and complement these previous investigations, and focused on two specific sampling media.

Quaternary deposits, predominantly till, were sampled during foot and helicopter traverses from over 350 sites. Soil profile sampling of B, BC and C horizons was completed where possible to determine the geochemical profile and the horizon most characteristic of the parent material. Similarly, vertical sampling was also undertaken within the C horizon to determine grain-size distribution changes as well as geochemical variations. Glaciofluvial outwash deposits were also sampled, but since their genesis entails both greater distances of transport and transport along less well defined flow lines compared to fill deposits, only a limited number of samples were collected. Surface sampling was carried out on a regional 2 x 2 km grid, with more detailed sampling (0.5 x 0.5 km grid) being done around and down-ice of the Strange Lake complex. In total, 757 samples were collected in 1984.

In addition to overburden sampling, lithological analyses were made of clasts from within till samples and of boulders on the till surface. The aim was to determine both glacial transport directions and distances within the study area. Strict bedrock control is required, but a review of the available geological data reveals that the gneissic terrane is unsuitable for use as indicator lithologies. Indicators may, however, be revealed from within the mineralized complex. Apart from these, adamellites are considered a suitable lithology due to their discrete occurrence in the western part of the study area and their distinct (highly weathered) character.

INITIAL RESULTS

Analysis of ice flow indicators reveals a remarkably consistent regional pattern across the study area. Ice flow directions are between 060 to 075 with a mean of 070. At individual sites, however, some variation is noted as ice is deformed around bedrock obstructions. These facts indicate that, firstly, topography did not determine ice flow in the Strange Lake area and, secondly, that ice was at or above the pressure melting point during the development of erosional features, most likely during the onset of glaciation.

Primarily on the basis of morphological evidence, three till types can be distinguished in the field area. The first unit was identified at only one locality. A trench on the Strange Lake deposit reveals a thin (50-60 cm), massive, overconsolidated unit with a silty to fine sandy matrix, comprising clasts of local origin. It is expected that the geochemical profile will be compatible with the underlying mineralized lithologies. These characteristics are similar to those expected for a lodgement till, and the unit is tentatively assigned this origin.

Overlying the lodgement till unit in the trench and ubiquitous over the rest of the study area is a sandy to silty-sandy matrixed unit. This unit is normally-consolidated, has micro-sorting evidenced in terms of small lenses of sand or silt and contains clasts of more distal origin compared to the underlying unit. Geochemically, it is expected to reveal a signature different from the lodgement till; this would be more evidence for further transport of this unit. Thicknesses of the melt-out till unit exceed 5 m in places in the field area, although more extensive thicknesses may be expected. On the basis of its characteristics and stratigraphic position relative to the underlying lodgement till, this unit is tentatively assigned a subglacial melt-out origin. An identifiable subunit has similar morphological characteristics to the melt-out till unit, but since it is found in the lee of large crags, forming till 'tails', the term lee-side till may be applicable. This subunit was formed as debris melted out and dropped into a cavity formed as ice moved over a bedrock obstruction. This differs from the melt-out tills, which formed as debris-rich ice stagnated and downwasted.

The third till is predominantly a boulder unit. Clasts are angular to subangular and show no evidence of basal transport. In all cases, this unit directly overlies the subglacial melt-out/lee-side till element. It is possible that this unit is a supraglacial melt-out, although it is realized that the morphological evidence also corresponds to a subglacial melt-out till origin. More analyses should help us to determine the origin of this unit.

The finer than 4φ (63 microns) fractions of till samples were analyzed for Cu, Pb, Zn, Co, Cd, Ni, Mn, Fe, Be, F, Li and U. In addition, Th, Rb, Sr, Y, Zr, Nb, Ga, La, Ba, V, Ce and Cr were analyzed by X-ray fluorescence. Data analysis and manipulation are ongoing, and some elements have been examined in terms of their aerial distribution (Figure 3). The Be and Pb data show a strong correlation to the peralkaline complex and are good indicators of the mineralization. The dispersal train is well developed and tails off in a downglacier direction; it declines sharply north and south of the dispersal train. This profile is similar to that found by McConnell et al. (1984). However, control in terms of consistent regional sampling will only be achieved with the addition of the 1984 data so further conclusions at this time are difficult.

Similarly, the character of the boulder shadow from the mineralization is still under investigation and awaiting more comprehensive data on the nature of the deposit. However, the boulder train exhibits well defined lithologic alignments parallel to flow, which may be related to discrete units within the Strange Lake Alkalic Complex.

Evidence from boulder and till geochemistry indicates at least 30 km of transport from the deposit. A lag from the edge of the complex to its expression in either boulder or surface geochemistry is evident. The length of this so-called 'k' value (Drake, 1983) is dependent upon a series of variables, primarily overburden thickness (Miller, 1984). However, the nature of the overburden deposits has already revealed two tills, possibly a lodgement and melt-out facies, which exhibit contrasting transport distances and characteristics. Clearly then, in an exploration program, the nature of the

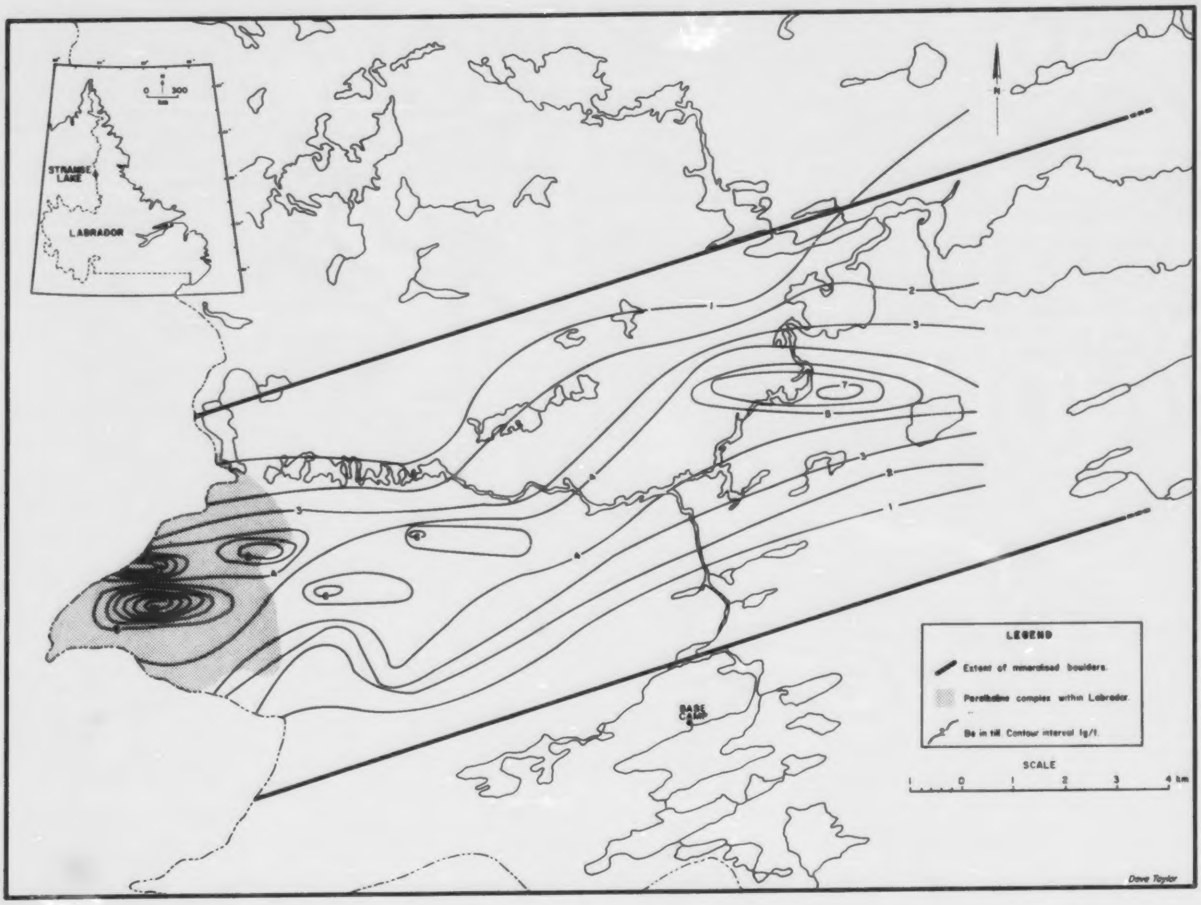
STRANGE LAKE
LABRADOR
0 300
km
N
BASE CAMP
LEGEND
Extent of mineralised boulders.
Peralkaline complex within Labrador.
Be in till. Contour interval 1g/t.
SCALE
1 0 1 2 3 4 km
Dave Taylor

Figure 3: *Geochemical/boulder dispersal from the Strange Lake deposit.*

facies being sampled is critical and, if ignored, could lead to erroneous conclusions regarding the location of areas of potential mineralization.

FUTURE RESEARCH

Determinations of the chemistry and grain sizes of the samples is ongoing. These data will be added to the data collected in 1983 to produce an overall picture of the geochemical signature of the deposit and provide an evaluation of the most useful parameters for characterizing this type of deposit. Similarly, the nature of overburden units will be assessed, in terms of their grain size and geochemistry, and other distinguishing characteristics for mineral exploration.

ACKNOWLEDGEMENTS

Numerous people and groups were involved in making this project a success and we wish to extend our thanks to all of them. The Wildlife Division of the Newfoundland Department of Culture, Recreation and Youth allowed us to use their cabin at Strange Lake, and Sealand Helicopters Limited supplied logistical support for the field work. Of special consideration are Mines and Energy personnel; Wayne Tuttle and Ken O'Quinn provided logistical support from Goose Bay, while Denis Fox, Sandra Hookey and Sharon Scott were excellent assistants, both in the field and the office. This report was improved by critical review from colleagues in the Quaternary Geology Section.

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AGGREGATE RESOURCE INVENTORY ALONG POSSIBLE ROUTES FROM STRANGE LAKE, LABRADOR TO THE ATLANTIC COAST

by

M.J. Ricketts and J.P. Hayes

ABSTRACT

This report describes an aggregate resources inventory conducted along a proposed transportation route across northern Labrador, from the Strange Lake mineral deposit to Anaktalak Bay, 32 km south of Nain. The study was conducted as an aid to the possible construction of a route to transport ore to the coast, from where it can be shipped to industrial markets. The route selected follows the prevailing topography, has abundant coarse granular materials, and appears to be the cheapest to construct.

INTRODUCTION

Development of the Strange Lake mineral deposit will require a transportation route to deliver the raw or partially refined ore to markets in Canada or elsewhere. Due to the easterly trend of the topography, it is assumed that a route might be constructed eastward to the Labrador coast. Therefore, a project was undertaken to provide relevant landform mapping and aggregate resource data. A route southward or westward would be longer, transverse to topography and vastly more difficult and costly to construct.

The main objective of the project was to determine the quantity and quality of aggregate material along proposed routes to the coast. Surficial maps derived from airphoto interpretation, covering a 6 km wide corridor to the coast, were used as a guide to delineate and sample areas of potential aggregates. The project involved the locating and detailed sampling of any aggregate reserves in the map area. Attention was also given to problem or hazardous areas such as rock falls along narrow valley segments. Water depths were estimated in areas where eskers have been dissected by streams or have terminated in lakes. Extensive stretches of bogland and rock outcrops along the route were also noted as well as potentially unstable areas such as those with large deposits of clay and silt or areas of permafrost.

REGIONAL SETTING

The Strange Lake deposit is situated on the Quebec-Labrador border approximately 130 km west of Nain, It is in a dissected plateau region approximately 500 m above sea level. Major steep-sided valleys incise the plateau to the east. Quaternary deposits in the Strange Lake area are composed predominantly of tills, with two glaciofluvial outwash systems evident near the deposit, one trending east-northeast toward the Fraser Valley and the second trending eastward toward Ikadlivik Brook. Most of the major valleys are filled with outwash material and have treed floors. Crag and tail hills are common, some having lengths greater than 2 km. There is about 20% bog cover and less than 5% rock exposure. The plateau is a treeless landscape covered by a tundra flora and lies within the zone of discontinuous permafrost (McConnell et al., 1984). Numerous ponds and lakes cover much of the area.

The general geology is composed of rocks of gneissic and granitic lithologies, e.g. paragneiss, felsic to intermediate gneiss, granitic gneiss, granite, anorthosite, migmatite and amphibolite (Figure 1).

FIELD PROGRAM

Field sampling was conducted at 1 km intervals or less along most sections of the proposed routes. Where possible, samples were taken from natural exposures such as stream cuts, lake shores and gullied areas. From these exposures, samples were obtained which were free of plant debris and topsoil. Where natural exposures were not present, samples were taken from hand-dug pits that extended into the C horizon, in order to provide a fresh sample unaffected by weathering. 282 samples were collected for particle size analyses and/or lithological investigation. Sample types collected were gravel (136), sand (89), sandy gravel (26), till (14), sand/silt (11), silt(4) and clay (2). Petrographic numbers (Canadian Standard Association, 1973) obtained from field pebble analyses range from 150-300, indicating hard, durable aggregates suitable for most construction purposes.

DATA ANALYSES

A main objective of the field sampling program was to obtain grain-size analyses on all samples containing particles greater than +8 mm. Laboratory analyses will be conducted on all -8 mm sample fractions returned from the field. These analyses will include drying and splitting of samples and dry sieving of fractions down to -0.062 mm (Kirby et al., 1983).

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

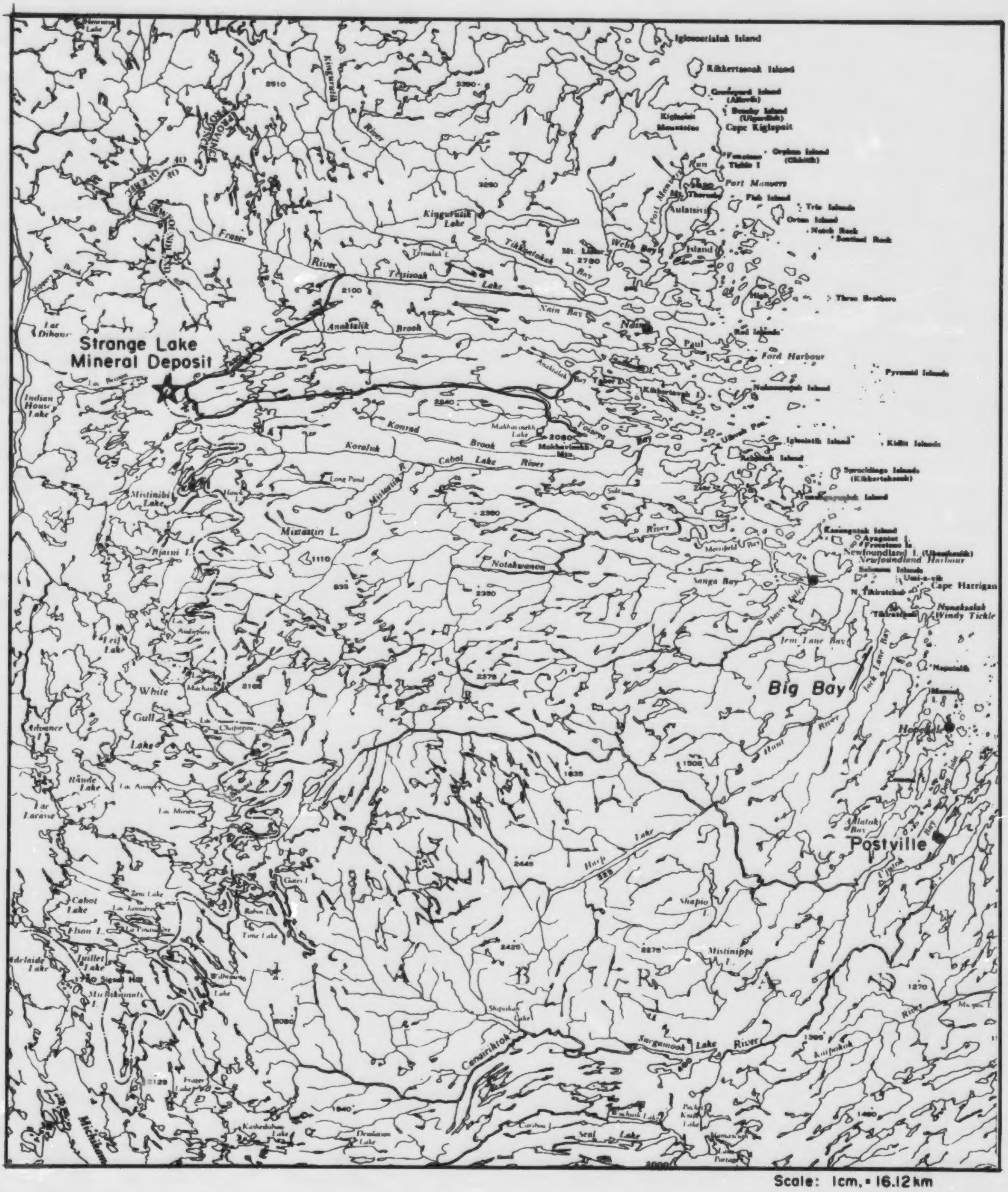

Figure 1: *Proposed Strange Lake transportation routes.*

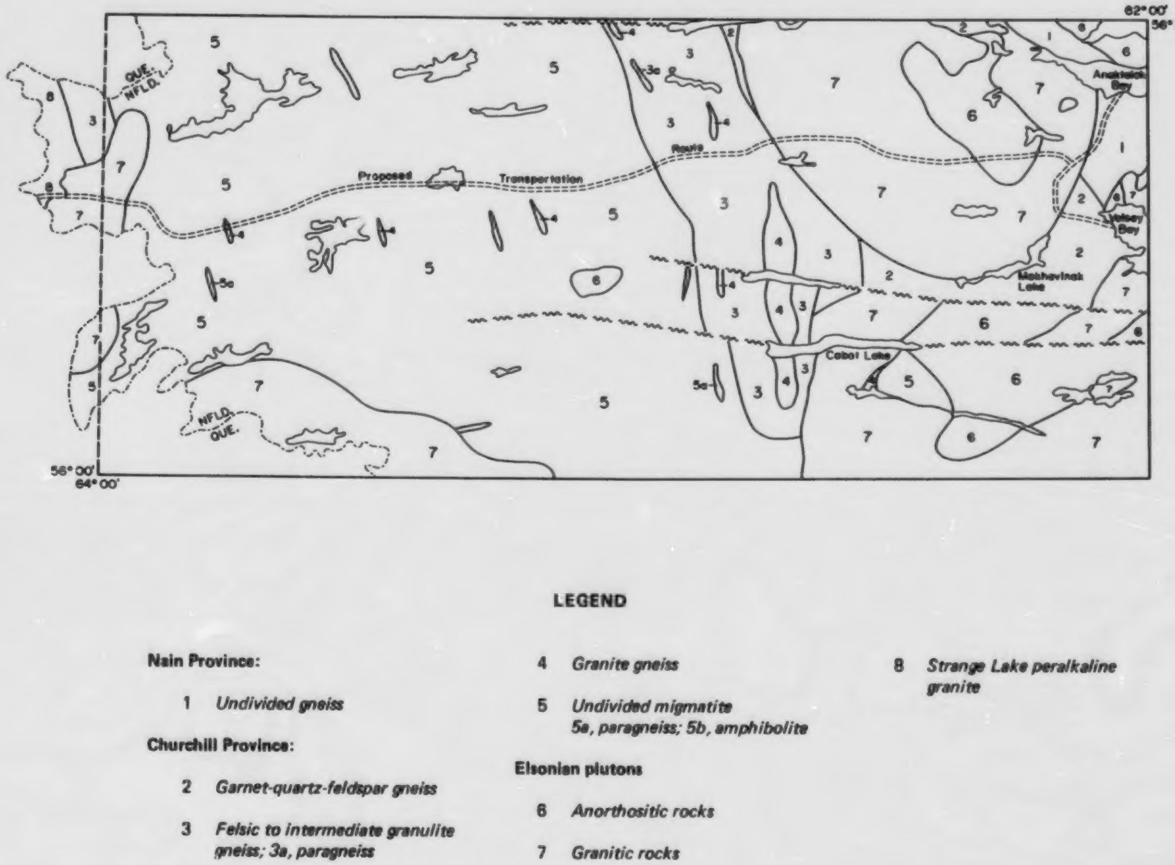

Figure 2: *Generalized geology along the proposed Ikadlivik Brook transportation route. Compiled by B. Ryan, Newfoundland Department of Mines and Energy.*

A database management system (Scientific Information Retrieval System) designed for storage and retrieval of aggregate and surficial geology data (Atkinson, 1984) will be used to record all field and laboratory data.

PROPOSED ROUTES

Two routes originating at the Quebec-Labrador border near the Strange Lake mineral deposit and extending in an easterly direction toward the Labrador coast were studied. Route one was toward the Fraser Valley, and route two was along Ikadlivik Brook toward Voisey Bay and Anaktalak Bay.

Fraser Route

The Fraser route follows a continuous sequence of glaciofluvial outwash deposits. It originates near the Strange Lake deposit and is dominated by a series of long sinuous esker ridges. The esker system, which occasionally exceeds 20 m in height, trends in a roughly east-northeast direction. This proposed route follows the esker system with only minor diversions as far as the Fraser River canyon. No construction problems are expected to this point. However, access down into the Fraser Valley to Tasisuak Lake would present a major problem.

The Fraser Valley is a glacial trough and tributaries enter the major valley through hanging valleys. The height difference between the plateau and the valley floor is approximately 500 m, much of which is accounted for by vertical slopes (Batterson and Vanderveer, 1984). A tributary valley issuing into Tasisuak Lake, located approximately 20 km east of where the glaciofluvial outwash systems terminate on the plateau, has slopes gentle enough to allow road construction. However, the 20 km route to this valley traverses an area of poor quality aggregate, composed mostly of a thin layer of silty till with associated mud boils, plus rock outcrops in several places. In addition, a number of gorges would have to be bridged or bypassed, increasing the cost and/or distance of construction.

If ore could be transferred from the plateau to the valley floor, other problems exist. Ocean-going vessels can traverse most of Tasisuak Lake, but the river mouth would have to be dredged or a series of locks constructed to provide an outlet to the ocean. Further, the Fraser River Valley in general and Tasisuak Lake in particular may have been deemed an arctic char protection area by the Federal Department of Fisheries and Oceans (Batterson and Vanderveer, 1984). It is therefore doubtful that any development would be permitted in the lake area. This route is less likely to be usable and was not studied in detail.

Ikadlivik Brook Route

The Ikadlivik Brook route, which was studied in greater detail, follows a glaciofluvial outwash system of considerable resource potential. This route is approximately 150 km long from the Strange Lake deposit site to Anaktalak Bay on the Labrador coast. It follows the Fraser route to 9 km east of the deposit, then turns south following two river channels for another 16 km to the next major eastward trending valley.

The 9 km section of the Fraser route is plotted along the top of a dissected esker composed of cobble-pebble gravel, with scattered boulders along parts of the ridge. Material along the river channels consists of fine sandy till, with a 2 km stretch of bogland separating the two channels. The bogland appears to be shallow, with scattered boulders protruding in places, and should not cause any major problem in construction. A more detailed study would be needed to determine the effects of permafrost on road construction in this area.

The route along the river channels joins a major esker/glaciofluvial outwash system which extends in an easterly direction across half of mapsheet 14D/5 and all of 14D/6, covering a distance of 53 km. The esker reaches heights of up to 20 m and is discontinuous, being dissected by either meltwater channels or channels connecting small lakes, or terminating in lakes. The aggregate along this section has a dominant gravelly texture, although boulder and sandy materials were sampled in several places. Water depths were taken at eight breaks in the esker system and ranged from 1.5-5.5 m. In those places where intervening waters are shallow, culverts and cut-and-fill operations could be employed. However, there are some places where currents are strong and a bridge or large culvert would have to be installed.

The esker system tapers off at the beginning of mapsheet 14D/7. A 6 km stretch of boulder till and fine sandy till was mapped to join up with the Ikadlivik Brook Valley. There are scattered mud boils and small patches of bogland along this section. The slope of the land is steep enough to allow adequate drainage by ditching if road construction occurs in the area.

Ikadlivik Brook has a well defined valley with sidewalls up to 140 m and a well developed valley floor. Abundant glaciofluvial outwash deposits are evident in the valley. These are largely kame deposits with associated kettleholes, and eskers. There is an abundance of good quality aggregate, although large deposits of sand, some silt and clays cover much of the lower part of the valley. Blasting of rock may be required at a few narrow sections along the valley. There are many rapids and shallow areas in the upper part of the valley, while in the lower half the river is deeper with fewer rapids.

Field work has been conducted along two access routes leading from Ikadlivik Brook to the ocean. One route extends past the confluence with Kogluklokoluk Brook and leads into Voisey Bay. The second route leads northward and exits Ikadlivik Brook via the Reid Brook Valley and terminates at Anaktalak Bay.

The Voisey Bay access route is approximately 0.5 km shorter than the Anaktalak Bay route and extends over an area containing granular material of predominantly sand size that overlies deposits of silt and clay. The stability of this route would have to be assessed for road construction. In addition, steep rock faces are an impediment in places, and water depth at the landward end of Voisey Bay may not be sufficient for ocean-going vessels. There are extensive shallows at the mouth of Ikadlivik Brook, although an adequate channel appears evident on the north side of the Bay opposite Garland Bight (Batterson and Vanderveer, 1984).

The alternative route, northward through the Reid Brook Valley, flows into Anaktalik Bay, which has deeper water than Voisey Bay. This route, although slightly longer, appears to be the best route to the coast. Deposits of coarser granular material were sampled along this route, along with sand, silt and clay deposits. Along both routes, bridges or large culverts would have to be installed to cross the numerous streams entering the main river system.

CONCLUSION

A suitable transportation route could be constructed from the Strange Lake deposit following an esker/glaciofluvial outwash system in an east-northeast direction toward the Fraser Valley. However, apparently insurmountable problems are encountered on reaching the Fraser River Valley, such as the nearly 500 m vertical drop at the entrance down into the valley, an arctic char protection area along the Fraser River, and dredging or the construction of locks at shallow areas near the mouth of the river to provide access for ocean-going vessels. Therefore, this route must be deemed unsatisfactory.

The Ikadlivik Brook Valley route is the most suitable one to the Atlantic coast. Along the plateau section, large aggregate deposits and the well developed esker ridge should provide a suitable route and adequate construction materials, although several streams must be traversed. In the Ikadlivik Brook Valley, access to the ocean can be achieved by a route northwards through the Reid Brook Valley or southward into Voisey Bay. The Reid Brook route into Anaktalik Bay appears to be the most appropriate choice because of a deeper bay and the availability of deposits of coarser granular material.

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We sincerely thank Martin Batterson and his surficial mapping crew for their cooperation and companionship and making it an enjoyable field season.

Doug Vanderveer and Martin Batterson critically reviewed the report and made substantial improvements.

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COASTAL LABRADOR COMMUNITY AGGREGATE RESOURCES

by

M.J. Ricketts

ABSTRACT

In 1984, two days of reconnaissance aggregate surveys were conducted in the coastal communities of Postville, Hopedale, Big Bay (which is a possible relocation site for Hopedale), Davis Inlet and Nain. This is a continuation of the 1983 aggregate studies (Ricketts and Bragg, 1984) conducted to aid community development and planning. Low quantities and poor quality of materials in most of these communities make proper resource management essential if reasonable construction costs are to be realised. Work in coastal Labrador communities was conducted in a similar pattern to the Inventory of Aggregate Resource Program (Kirby et al., 1983).

INTRODUCTION

The Coastal Labrador Aggregate Resource Project was started in 1983 with the objective of mapping aggregate resources in and around isolated coastal communities. Particular aims of the project are to designate areas for extraction in specific planning proposals (e.g. municipal plans), and to ensure that aggregates are preserved to meet present and future demand in any area. It was planned to complete detailed sampling over a two-year period for coastal communities from Lodge Bay in the south to Nain in the north.

In 1983, the project was funded by the Newfoundland Department of Mines and Energy and the Canadian Department of Regional Economic Expansion (Coastal Labrador Subsidiary Agreement). During 1983, field work was completed in Lodge Bay, Mary's Harbour, Port Hope Simpson, Charlottetown, Fox Harbour, Black Tickle, Paradise River, Cartwright and Rigolet. Two sets of maps were compiled, consisting of fifteen maps each. One set includes sample localities and zones of aggregate potential; the other shows surficial geology (landform classification).

In 1984, there was no funding to continue this work and so field operations had to be greatly restricted. As a result, only two days of reconnaissance work were carried out in Postville, Hopedale, Davis Inlet and Nain, which were not sampled in 1983 (Figure 1).

OBJECTIVES

The main objective of this program was to map deposits of sand, gravel, stone, etc., suitable for construction purposes. There is a great need for this type of mapping in Labrador because of the lack of readily available information or mapped data and general lack of overburden and granular materials in many of these areas.

In cooperation with municipal or community councils, the intent is to delineate resource sites and have them protected by zoning within municipal plans. Proper resource management is essential in many areas. High grade aggregates should not be used for subgrade (ballast or fill) materials but should be reserved for future road topping or concrete uses in local communities. In areas lacking quality grade aggregates, alternative sources such as till with a low silt/clay content and/or suitable bedrock could be used.

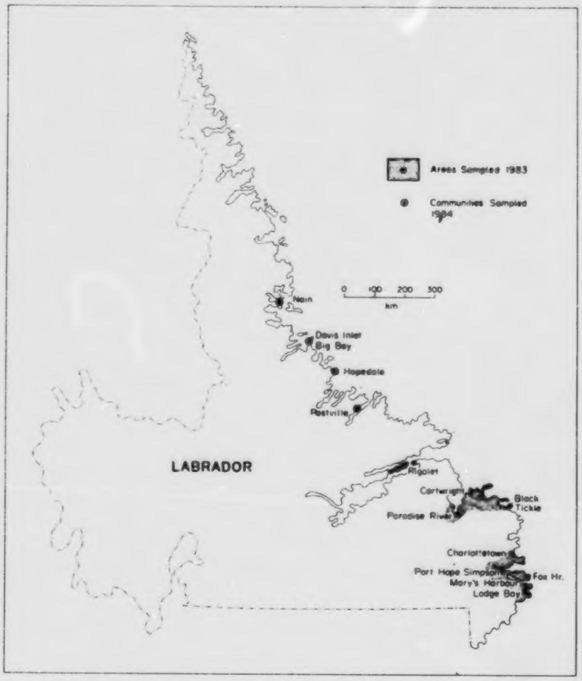

Figure 1: *Aggregate resources - coastal Labrador.*

Another objective of the project was to identify surficial (surface) landforms to assist land use planning for various community needs such as housing, recreation, roads and servicing; as well as providing data on the geotechnical properties of the subsoil, overburden and bedrock materials to assist pre-engineering studies of route selection for roads and water or sewage mains.

DATA ANALYSES

The grain size distribution of granular deposits sampled in the field will be determined by laboratory sieve analyses. These analyses will include drying and splitting of samples and dry sieving of samples down to -0.062 mm (Kirby et al., 1983).

A database management system (Scientific Information Retrieval System) designed for storage and retrieval of aggregate and surficial geology data (Atkinson, 1984) will be used to record all field and laboratory data.

RECONNAISSANCE AGGREGATE SURVEYS

Reconnaissance aggregate surveys were conducted in the four most northern communities within the study area. Surficial geology maps, based on airphoto interpretation at 1:50,000 scale, were generated and field work included spot sampling and generalized note taking in areas visited.

Postville. This community is located in an area of till veneer (0-1 m) and exposed bedrock, with sparse to moderate tree growth and low bush vegetation. The general geology is composed primarily of granitic and granodioritic gneiss (Taylor, 1970). A deltaic deposit within the community will supply local demand for many years, although about 40% of this deposit was mined for use on the airstrip completed in 1984. This deposit contains various grades of material varying from silty sand and sand to sandy or cobbly gravel. This is the only known accessible deposit of good quality aggregate within a 10 km radius around the community. There are some large deposits on the eastern side of Kaipokok Bay but these are only accessible by boat or barge, which would greatly increase costs to local residents.

Hopedale. Hopedale has no large amounts of surficial material (Fulton et al., 1975) but has enough soil in cracks and hollows of the rock to allow for small shrub and bush growth in places. Exposed bedrock is the dominant landform in this coastal community. It is surrounded on three sides by rock slopes and is located in similar geological terrain to Postville. There is little available flat land for community expansion. Water and sewage projects or airstrip construction would be expensive because ditches would have to be blasted and all granular materials would have to be obtained by blasting and crushing. One limited shallow till deposit near the community is of poor quality, containing many boulders and a high concentration of iron oxide. This is currently being used for fill. Any community developments or housing will require that aggregate materials be brought in or that bedrock be blasted and crushed.

Big Bay. A reconnaissance aggregate survey was carried out in the Big Bay area to provide information on a possible relocation site for the community of Hopedale. Big Bay is located approximately 42 km (by water) north of Hopedale, at the mouth of the Hunt River. The bay is over 25 km long and has shallow areas extending 20-30 m offshore in most places. There is a high percentage of flat or gently sloping land on both sides of the bay, with dense forest growth covering most areas near the shoreline and a few large bogs (some over 2 km in length) located on the eastern side. Mountain peaks on both sides reach elevations greater than 200 m above sea level. The Hunt River, flowing northeastward into Big Bay, is a popular sports fishing area for salmon. Two fishing camps were in operation on the river during the 1984 salmon fishing season.

Aggregate reconnaissance work has shown the area to contain large deposits of glaciofluvial outwash material. A possible raised marine beach ridge was sampled between 10-12 m above sea level on the eastern side of the bay. Two samples indicate sandy and sandy/cobbly gravel textures. If Hopedale is relocated here, there appear to be adequate granular resources for construction purposes, and the nature of the unconsolidated overburden should make servicing (i.e. roads, water and sewer lines, etc.) comparatively easy.

Davis Inlet. The rocks in this area are composed primarily of anorthosite (Taylor, 1970) and the area is surrounded by a dominant spruce tree growth vegetation. There is only one large surficial deposit in the general area. This is an outwash deposit located 1 km northeast of the community, near the end of the airstrip. This outwash material is composed of fine to medium grained sand with some pebbles, but is not satisfactory for good quality concrete or road surfacing gravel.

Nain. Nain is the northernmost community studied under this survey. The geology is similar to that of Davis Inlet. Rock outcrops are dominant on the surrounding hills, with sparse to moderate tree growth in the valleys. Nain has adequate deposits of outwash material, composed of fine to medium sands with some pebbles, but lacks good quality concrete or road surfacing aggregates.

CONCLUSION

With the low quantity and quality of aggregate in most coastal communities, plans should be made now for future developments. Any major projects (e.g. airstrips, road building, water and sewer projects) in some of these areas will require aggregate production by blasting and crushing of bedrock. If equipment for such projects is brought into a community, local councils should crush and stockpile additional materials to meet their future requirements (e.g. 10-15 years). The long-term gains of reduced construction costs would more than offset the initial cost outlay since mobilization costs for the blasting and crushing equipment often represent up to 50 percent of present contracts.

In areas with adequate aggregate deposits, the designation of aggregate zones within specific locations will ensure that aggregate can be preserved to meet the future demands of the domestic and commercial aggregate consumer. After the aggregate resources are depleted, quarry areas should be rehabilitated to a condition suitable for other uses, such as housing and recreation.

A preliminary report for coastal community areas will be released in 1985; a comprehensive final report will be published in 1986.

ACKNOWLEDGEMENTS

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GEOLOGY OF THE PARADISE RIVER REGION, GRENVILLE PROVINCE, EASTERN LABRADOR

Project J.1.9.2.

by

Charles F. Gower, Nathaniel Noel and Timothy Van Nostrand

ABSTRACT

The Paradise River region is located in the Lake Melville terrane of the Grenville Province, eastern Labrador. Four major lithological associations were mapped, namely (i) orthogneiss, (ii) metasedimentary gneiss, (iii) anorthositic-gabbroic-monzonitic rocks, (iv) granitoid plutons. Orthogneiss is found in discrete belts that flank, or occur within granitoid plutons, and above thrusts. It is, at least in part, the tectonized equivalent of the granitoid plutons. Metasedimentary gneiss is dominated by biotite-sillimanite-garnet bearing pelites, but psammitic gneiss, quartzite and calc-silicate rocks are locally present. Most anorthositic-gabbroic-monzonitic rocks are grouped as the White Bear Arm complex, which shows well preserved primary fabrics in its interior but has a highly tectonized, thrust-bound margin. A sheet of recrystallized anorthosite also occurs in the southwest quadrant of the study area. The granitoid plutons are divided into two groups, namely (i) diorite, monzonite and granodiorite belonging to the Earl Island domain (of the Groswater Bay Terrane), (ii) an intergradational plutonic package of megacrystic and non-megacrystic granodiorite, monzonite, granite and alkali-feldspar granite mostly in the Lake Melville terrane. In addition to these lithological associations, other rocks mapped include mafic intrusions of various ages, including Lower Phanerozoic north-northeast trending mafic dikes.

The regional structure is controlled by two major northwest trending zones of ductile deformation, and the thrust-bounded White Bear Arm complex. The departure of structures in the central and northwest parts of the region from the regional northwest trend is attributed to the collective effects of the strike dip and thrust faults. This interpretation is extended to a regional structural synthesis of the Lake Melville terrane. Faulting related to the newly recognized Sandwich Bay graben has little effect on earlier structural patterns.

Prospects for economic mineralization appear to be confined to sulfide-rich zones in metasedimentary gneiss, radioactive granitoid rocks and mica-rich pegmatite.

INTRODUCTION

A major 1:100,000 scale reconnaissance mapping program in the Grenville Province of eastern Labrador commenced in 1979 in the Makkovik Province and adjacent northern fringe of the Grenville Province and between 1979-1984 regional mapping coverage has gradually advanced southward. Mapping in the Paradise River region in 1984 (outlined in Figure 1), represents an extension of that coverage, and at the same time the start of a new 5-year Canada-Newfoundland joint project that will complete 1:100,000 scale geological mapping of an 80 km wide coastal fringe of the Grenville Province in eastern Labrador.

The Paradise River region comprises four NTS 1:50,000 sheets (13H/3,4,5,6) which encompass an area of approximately 3700 km^2. The only previously published geological map which includes the whole of the map area is that of Eade (1962) at 1:500,000 scale. Eade showed the area to be underlain mainly by granitic gneiss, lesser metasedimentary gneiss, granite to granodiorite plutons, and gabbroic to anorthositic intrusions. More recently, much of the northern part of the area was re-examined by Cherry (1978a,b). Cherry depicted the area as largely underlain by schlieric migmatite gneiss with the distribution of metasedimentary gneiss essentially unchanged from Eade's map.

Mineral exploration has been carried out intermittently by BRINEX Ltd. Initial geological mapping and mineral potential evaluation was carried out in 1954 by (Piloski, 1955) who recommended the area as favourable for U, Cu, Ni and Au mineralization. Airborne magnetic and electromagnetic surveys were flown in 1959 (Wilson, 1959) and a combined geological, lake sediment geochemical, ground electromagnetic and prospecting program was undertaken in 1965. Results are summarized in a report by Sutton (1965) with appendices by Juilland (geology), Meyer (geochemistry), Staub (ground geophysics), and Cote and Anderson (laboratory methods). Active interest by Brinex ceased after further reconnaissance geological mapping by Kranck (1966) although the Ni potential of the region was subsequently reviewed for BRINEX by Westoll (1971).

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

The present mapping, benefit from complete aeromagnetic map coverage (Geological Survey of Canada, 1974a,b,c,d,e) and mapping experience gained in similar rocks farther north (Gower et al., 1981, 1983a,c; Owen et al., 1983). Mapping has resulted in considerable refinement of rock type distribution and protolith identification, and has permitted an initial attempt at regional structural synthesis of the Lake Melville terrane.

REGIONAL SETTING

The study area is situated entirely within the Grenville Province and, except for the northeast corner, is an extension of the Lake Melville terrane (Gower, 1984; Gower and Owen, 1984). The northeast corner of the map area, a lithologically distinct part of the Groswater Bay terrane, is informally referred to in this paper as the Earl Island domain. The location of the study area and major (litho) tectonic subdivisions recognized in the Grenville Province of Labrador are shown in Figure 1. Ornamentation in Figure 1 is intended to depict lithotectonically correlative regions, although names of (litho) tectonic subdivisions are those used locally. Further reference is made to these areas with respect to structural synthesis.

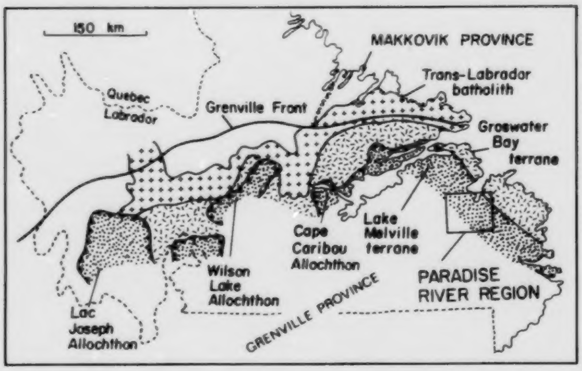

Figure 1: *Major structural features of the Grenville Province, Labrador. Distribution and names of allochthons in central and western Labrador are from Ryan et al. (1982), Rivers and Nunn (in press) and Thomas et al. (in press). Location of paradise River region outlined.*

DESCRIPTION OF ROCK UNITS

Orthogneiss

All rocks mapped as orthogneiss are located in the western half of the study area and occur as narrow belts less than 4 km wide. These are marginal to other rock types, especially granitoid plutons, or to major structures such as thrusts. In Figure 2 the orthogneisses have been subdivided into three units but all have, in part, a well-banded, migmatitic aspect. The units are entirely intergradational, hence no boundaries are drawn on the map. Undoubtedly, in detail, the interfingering of the various orthogneiss types is more complex than shown but even where outcrop permits we do not believe that more detailed mapping will significantly change the regional distribution patterns depicted. These rocks are not necessarily the oldest in the area, as will become clear in the ensuing description.

The biotite hornblende granodiorite-diorite-amphibolite unit is characterized by ubiquitous hornblende. The amphibolites are amphibole-plagioclase±pyroxene rocks with local orthopyroxene bearing leucosome patches (Plate 1). They have a strongly foliated, lensy to well-banded appearance. The most extensive amphibolitic gneiss occurs marginal to a thrust northeast of Crooked Lake (Figure 2). The gabbroid rocks on the hanging wall of the thrust are amphibolite in part and it is quite probable that the underlying amphibolitic gneiss simply represents similar rocks which have experienced more intense strain and migmatization in a series of structurally lower thrust slices. Amphibolitic gneiss elsewhere is mostly restricted to single outcrop; rarely seen local discordance to an earlier fabric demonstrates that these gneisses are highly deformed mafic dikes.

The dioritic and hornblende-bearing granodiorite gneisses are medium grained, migmatitic, variably banded rocks. Northeast of Crooked Lake, these gneisses separate the amphibolites and quartzofeldspathic gneisses and are interpreted to result from the thorough interleaving and migmatization of the amphibolitic and quartzofeldspathic protoliths. Elsewhere, these gneisses occur in areas commonly less than a few km^2 and are interpreted as small deformed plutons or tectonized margins of larger hornblende-bearing intrusions.

Biotite granodiorite gneiss is the most extensive orthogneiss rock type. It is a creamy weathering, medium grained, weakly to well-banded rock, locally with common amphibolite lenses and crosscut by discordant minor granitic intrusions. Garnet occurs sporadically. The unit also includes minor tonalite, quartz diorite and quartz monzondiorite gneiss.

Biotite granite gneiss occurs as a pink to red weathering, fine to medium grained gneiss, locally with biotitic schlieren or amphibolite layers, which occurs principally in the central part of the map area. The unit is probably derived from minor

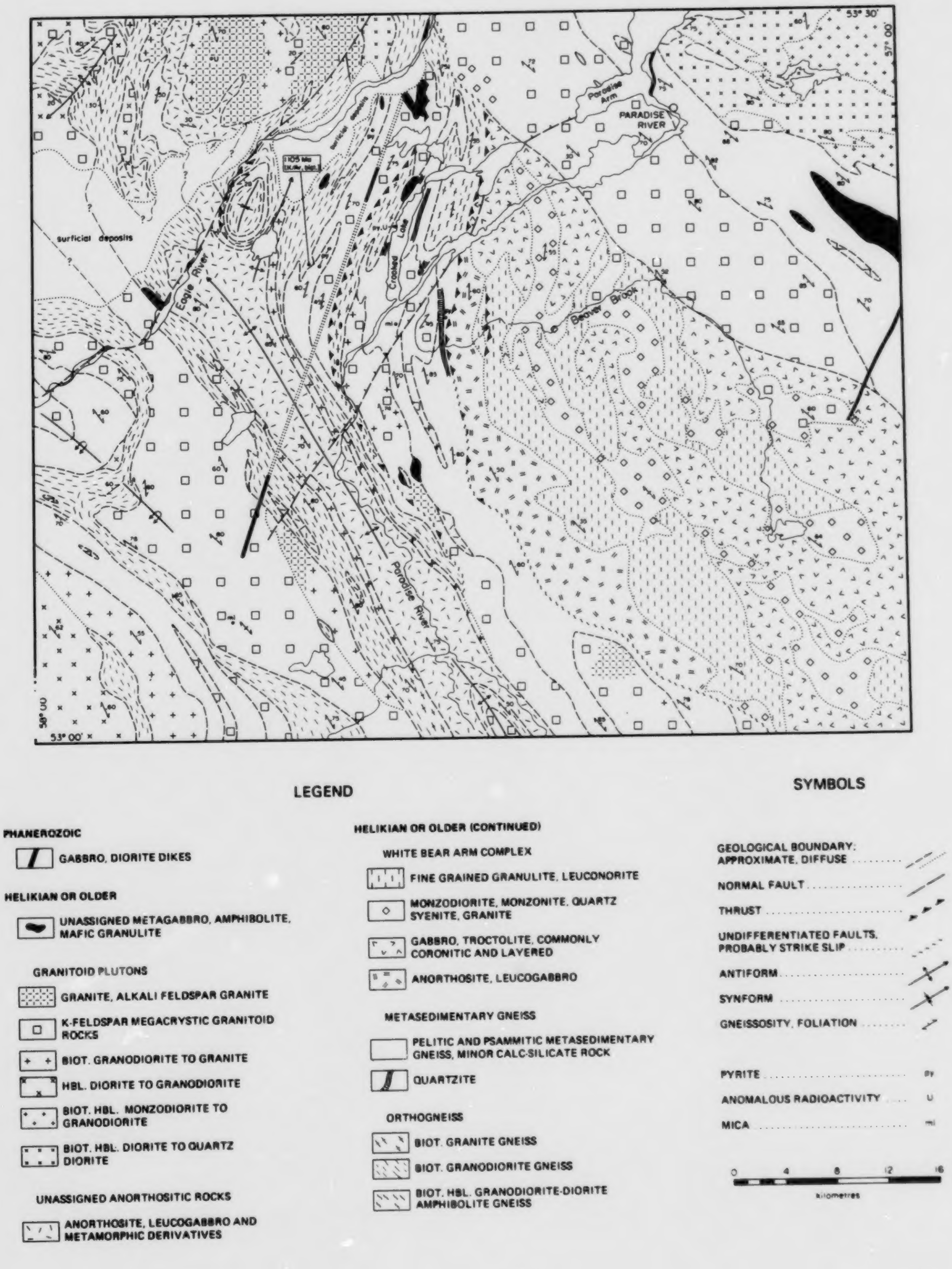
53° 30'
57° 00'
Paradise Arm
PARADISE RIVER
1105 Ma (K/Ar, biot.)
surficial deposits
Eagle River
Crooked Lake
Beaver Brook
Paradise River
58° 00'
53° 00'
LEGEND
PHANEROZOIC
GABBRO, DIORITE DIKES
HELIKIAN OR OLDER
UNASSIGNED METAGABBRO, AMPHIBOLITE, MAFIC GRANULITE
GRANITOID PLUTONS
GRANITE, ALKALI FELDSPAR GRANITE
K-FELDSPAR MEGACRYSTIC GRANITOID ROCKS
BIOT. GRANODIORITE TO GRANITE
HBL. DIORITE TO GRANODIORITE
BIOT. HBL. MONZODIORITE TO GRANODIORITE
BIOT. HBL. DIORITE TO QUARTZ DIORITE
UNASSIGNED ANORTHOSITIC ROCKS
ANORTHOSITE, LEUCOGABBRO AND METAMORPHIC DERIVATIVES
HELIKIAN OR OLDER (CONTINUED)
WHITE BEAR ARM COMPLEX
FINE GRAINED GRANULITE, LEUCONORITE
MONZODIORITE, MONZONITE, QUARTZ SYENITE, GRANITE
GABBRO, TROCTOLITE, COMMONLY CORONITIC AND LAYERED
ANORTHOSITE, LEUCOGABBRO
METASEDIMENTARY GNEISS
PELITIC AND PSAMMITIC METASEDIMENTARY GNEISS, MINOR CALC-SILICATE ROCK
QUARTZITE
ORTHOGNEISS
BIOT. GRANITE GNEISS
BIOT. GRANODIORITE GNEISS
BIOT. HBL. GRANODIORITE-DIORITE AMPHIBOLITE GNEISS
SYMBOLS
GEOLOGICAL BOUNDARY: APPROXIMATE, DIFFUSE
NORMAL FAULT
THRUST
UNDIFFERENTIATED FAULTS, PROBABLY STRIKE SLIP
ANTIFORM
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Figure 2: *Geology of the Paradise River region.*

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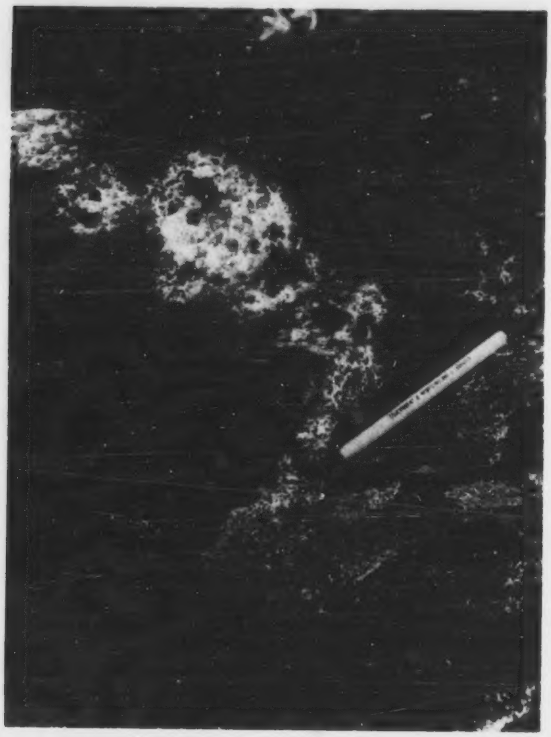

Plate 1: *Orthopyroxene in quartzofeldspathic leucosome patches in amphibolite associated with orthogneiss.*

granitoid intrusions or, less likely, arkosic metasediments.

Metasedimentary Gneiss

Metasedimentary gneiss occurs in three major linear zones in the northeast, central and southwest parts of the map area. All are dominated by sillimanite-garnet-biotite pelitic and semi-pelitic gneiss, but psammitic gneiss, diatexite, quartzite, and, rarely calc-silicate rocks and mafic supracrustal rocks are present. Pelitic gneiss is characteristically rusty, creamy or gray weathering, medium grained and well-banded. It is migmatitic with a restite comprising fibrous or prismatic sillimanite, mauve garnet, biotite, graphite and magnetite and leucosome pods or fine laminations of quartz + plagioclase + K-feldspar (Plate 2). Muscovite, probably retrograde is locally present in the pelitic gneiss (especially north of the community of Paradise River) and may also be found in late discordant pegmatites within the paragneiss. White weathering diatexite with abundant garnet is particularly common in the southwest metasedimentary gneiss belt and is interpreted as a partial melt product from the pelitic gneiss. The psammitic gneisses are closely associated with the pelitic gneiss, differing mainly in having a slightly coarser grained, more sugary appearance and lacking sillimanite. Garnet is typically wine colored rather than the distinctive mauve as in the pelites.

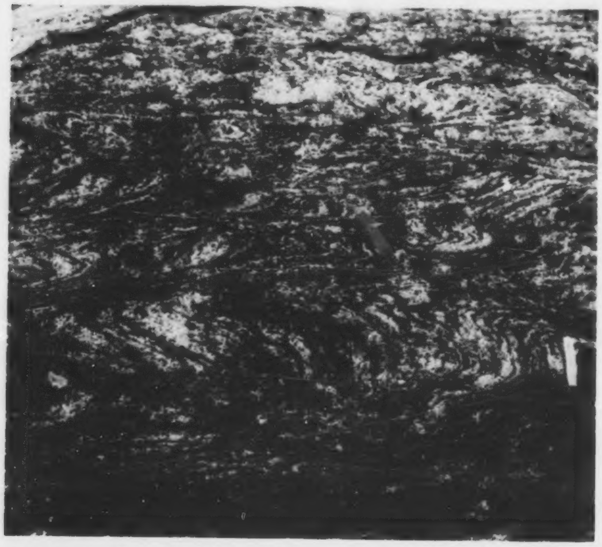

Plate 2: *Sillimanite bearing metasedimentary gneiss showing tight folding and transposition of fold limbs.*

Quartzite is a major rock type in the central metasedimentary gneiss belt east of Crooked Lake (Figure 2). It was first reported by Piloski (1955) and subsequently mentioned by Eade (1962), Kranck (1966) and Cherry (1978a,b). Only Kranck made any attempt to show its distribution. The band shown on Figure 2 east of the south end of Crooked Lake corresponds to one of his mapped quartzite units. It occurs in white weathering, massive to thickly bedded layers interbanded with psammitic and pelitic gneiss. Although much of the unit is pure quartz it also contains magnetite, graphite, garnet, biotite and feldspar, especially in thin beds. Kranck also mapped quartzite just southwest of Crooked Lake. Present mapping indicates that quartzite is a subordinate rock in this area, occurring as thin beds within sillimanite-bearing pelitic gneiss. Quartzite is also found as thin layers associated with pelitic gneiss in the southwest metasedimentary gneiss belt and with probable mafic supracrustal rocks in the northeast belt.

The mafic supracrustal rocks are confined to one shoreline locality 4 km north of Paradise River (community). The rocks are fine grained amphibolites with epidote-plagioclase-diopside-grossularite pods and discontinuous melanocratic seams.

In less intensely metamorphosed and deformed rocks (e.g. some Archean greenstone belts) such calcic material and melanocratic seams can be identified as interpillow mesostasis and pillow margins respectively. A pillow-form mafic lava or hyaloclastite protolith may therefore be applicable to this locality. Similar rocks occur on the southeast shore of The Backway (see Gower et al., 1983b) and at Dead Islands (52°48'N, 55°55'W) (Gower, personal observation). These are the only known mafic supracrustal rock localities in eastern Labrador, and the occurrences appear to be confined to a single metasedimentary belt at the northern fringe of the Lake Melville terrane. As all three occurrences are shoreline outcrops it is possible that this recessive-weathering unit occurs inland and is a characteristic feature of this particular metasedimentary belt.

Fine grained schistose mafic rocks were also observed 4 km east of Crooked Lake, where the thrust crosses Paradise River. A mafic supracrustal protolith is conceivable for these rocks also, but their structural position, adjacent to a thrust, and association with tectonic enclaves of metamorphosed layered gabbro suggest derivation from a highly deformed metagabbro.

Calc-silicate rocks, noted previously by Eade (1962) and Cherry (1978a,b) are not abundant and were only observed on either side of the south end of Crooked Lake. The rocks consist of quartz + grossular/andradite + diopside + calcic plagioclase and most commonly are present as boudinaged pods.

White Bear Arm complex

The White Bear Arm complex (WBAC) is an informal name introduced here for an anorthositic-gabbroic-monzonitic layered intrusion and associated mafic granulite, the northwest end of which underlies much of the eastern part of the map area. The WBAC was first named White Bear Arm gabbro by Piloski (1955) and referred to as White Bear Arm norite and White Bear Arm pluton by Wardle (1976). The type locality is at White Bear Arm on the southeast Labrador coast. The continuity of the WBAC from the coast to the present area (approximately 125 km) was suggested by Piloski (1955). We have not examined the ground between the coast and the Paradise River map area, but by using geophysical data and earlier mapping it appears appropriate to apply the name in the Paradise River area. The WBAC is not well exposed and the distribution of the four lithological subdivisions shown in Figure 2 must be considered tentative.

The anorthosite/leucogabbro unit has been identified only on the southwest flank of the WBAC and is a white or grey weathering, medium grained recrytallized rock. The mineralogy consists of plagioclase, clinopyroxene, orthopyroxene and hornblende with minor garnet and quartz. Locally recrystallized clusters of mafic silicates attest to derivation from a much coarser-grained protolith. However, because of its position adjacent to a major thrust, intense deformation has obliterated original textures.

Gabbro-troctolite rocks were mapped mostly in the center zone of the WBAC and amphibolitic rocks, interpreted as metamorphosed equivalents, have been included under the same ornamentation in Figure 2. Amphibolite is most abundant on the northeast flank of the WBAC and at its northwest tip.

In the center of the complex, gabbroid rocks are massive and primary plagioclase, olivine, clinopyroxene and orthopyroxene are preserved. Well-developed double orthopyroxene-amphibole coronas marginal to olivine also occur. Igneous layering, rhythmic in places, is present, especially in the southeast corner of the study area. Retrogression of pyroxene to amphibole is evident, particularly in rocks injected by either pegmatite or quartz-feldspar veins, and in those rocks having a marked metamorphic fabric.

Rocks grouped in the legend as monzodiorite, monzonite, quartz syenite and granite are creamy-brown to pink weathering, fine to coarse grained rocks and grade into K-feldspar or plagioclase megacrystic varieties. In places the monzonite-syenite clearly intrudes earlier mafic rocks, producing an agmatite with well-defined reaction rims at felsic-mafic interfaces (Plate 3). Elsewhere the monzonites contain irregular mafic enclaves which show K-feldspar megacrysts rimmed by plagioclase and large quartz crystals identical to the host monzonite. Some of the enclaves have chilled margins (texturally distinct from the reaction rims alluded to earlier) and are almost certainly mafic dikes. These apparently contradictory intrusive relationships will be evaluated when petrographic data are available.

The "fine grained granulite, leuconorite" unit is shown as underlying large areas of the WBAC (Figure 2). However, because of the fine grain size and rectiplanar shape of many outcrops we suspect that they may be mafic dikes with a granulite facies mineralogy. As the fine-grained granulites occur as isolated, resistant outcrops without an intervening contrasting rock type we have little choice but to depict distribution as shown.

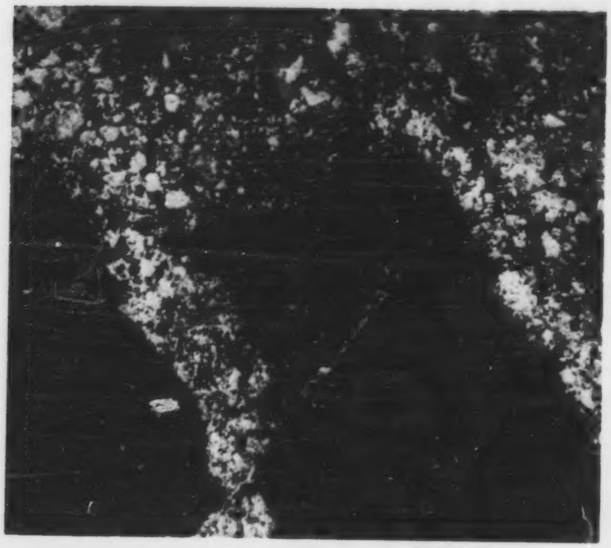

Plate 3: *Monzonite-syenite of White Bear Arm complex intruding earlier mafic rocks producing an agmatite with well-defined reaction rims of felsic-mafic interfaces. Reaction rims 2 cm wide.*

Unassigned Anorthositic Rocks

Distinctive, recessive-weathering anorthositic rocks are well exposed between Eagle River and the southern map boundary. Northwest of Eagle River, because of thick surficial deposits, their distribution is larely conjectural. The rock type is white to grey weathering, medium grained, recyrstallized and commonly strongly foliated. It consists of plagioclase, amphibole, pyroxene, with minor garnet and biotite. Coarse grained to extremely coarse grained primary textures are preserved in places. Poikilitic crystals over a metre in diameter were seen on upper Paradise River and individual pyroxenes over 25 cm long are not unusual. Amphibole in places partially replaces primary pyroxene; elsewhere former primary mafic silicates are now aggregates of amphibole, epidote (rare) and biotite. Primary layering is well preserved at the nose of the antiform near the south boundary of the map area (Plate 4). The presence of biotite granodiorite gneiss and megacrystic granodiorite in the core of the antiform constrain the thickness of the anorthosite to a maximum of 3 km.

Identical rocks outcrop along Alexis River west of Port Hope Simpson (C. Gower, personal observation, 1984) and geophysical data indicate that this unit is continuous between Eagle River and the southeast Labrador coast.

Plate 4: *Well-preserved primary layering in the unassigned anorthosite unit.*

Granitoid Plutons

The granitoid plutons are divided into two groups, namely (i) an association of relatively melanocratic diorite, monzodiorite and granodiorite belonging to the Earl Island domain in the northeast corner of the map area, (ii) an intergradational granodiorite to granite plutonic package subdivided into four units which occurs throughout the remainder of the map area.

The granitoid plutonic rocks of the Earl Island domain are medium grained, hornblende-biotite-plagioclase-quartz rocks with minor garnet and K-feldspar and are subdivided into two groups in Figure 2. Fabric varies from weakly foliated to gneissic, the latter being accompanied by a quartz-feldspar leucosome. Amphibolitic bands, probably representing deformed mafic dikes, are common. Quartz diorite is depicted north of lower Eagle River in Figure 2. These fine to medium grained recrystallized hornblende + biotite ± garnet rocks are mineralogically similar, but not obviously related to those in the Earl Island domain.

We describe the remaining granitoid plutons from northeast to southwest. The Paradise Arm pluton (new informal name), southwest of Paradise River (community), was first mapped on the Sandwich Bay 1:100,000 sheet area (Gower et al., 1983) and, with a length of at least 48 km, is the largest K-feldspar rich pluton mapped within the Grenville Province of eastern

Labrador. It is a medium to coarse grained K-feldspar megacrystic rock with a variable composition including granodiorite, granite, monzogranite or syenogranite. Much of this compositional range is due to variable megacryst abundance which locally exceeds 40% of the rock. Megacrysts exceed 7 cm long in places. Plagioclase also may occur as megacrysts, but rarely larger than 1 cm in diameter. Mafic phases are hornblende and garnet. The northeast side of the pluton is interpreted as a fault, based on a single mylonitized outcrop near Paradise River (community). The southwest side appears to be intrusive in the vicinity of Beaver Brook but close to Eagle River it is tectonic. There appears to be a complete lithological gradation between the monzonite of the White Bear Arm complex and the Paradise Arm pluton. Coupling this fact with their spatial juxtaposition leads us to suspect a genetic link.

The belt of granitoid plutons crossing the central part of the map area comprises dominantly K-feldspar megacrystic rocks. Specific granitoid types include granodiorite, monzogranite, granite and alkali feldspar granite. These rocks differ from the Paradise Arm pluton in having smaller K-feldspar megacrysts and lacking plagioclase megacrysts. The rocks are fine to medium grained, recrystallized, pink, creamy or brownish weathering rocks with biotite ± hornblende ± garnet as mafic phases. At many localities the rocks are strongly deformed, even mylonitic, and some rocks mapped as orthogneiss in the region are almost certainly extremely deformed and migmatized equivalents. For example, we infer that the biotite granodiorite gneiss on the hanging wall of the thrust west of Crooked Lake is correlative with the adjacent granitoid pluton and that the thrust transects a pluton that was formerly continuous across the map area.

The granitoid plutons in the northwest corner of the map area can be divided into two groups, alkali-feldspar granite in the east and amphibole-bearing K-feldspar megacrystic granitoid rocks farther west. The alkali-feldspar granite is a pink weathering, coarse grained rock with biotite schlieren, amphibolite enclaves and a few syenitic to granitic late stage dikes. It has a distinct radioactive element signature with total scintillometer counts usually 3 times normal background (200 cps) for such rocks and on one outcrop 20 times background.

The megacrystic granitoid plutons in the northwest corner consist of buff to pink weathering, medium grained, recrystallized biotite hornblende granodiorite to granite. Similar rocks were mapped in the Sandwich Bay 1:100,000 sheet (Gower et al., 1983) and are probably regionally correlative with those in the Paradise River area.

The large K-feldspar megacrystic granitoid pluton in the southwest part of the map area (Plate 5) is a pink weathering, medium to coarse grained, biotite-bearing granodiorite, granite or alkali-feldspar granite with common amphibolite enclaves. It is particularly characterized by abundant pegmatite with large magnetite crystals and books of biotite exceeding 10 cm across in places. It has a strongly deformed to mylonitic fabric.

Plate 5: *Strongly deformed K-feldspar megacrystic granitoid pluton and late pegmatite dike.*

The granitoid pluton in the southwest corner of the map area is a pink to rusty-cream weathering medium-grained, recrystallized rock with a biotite-dominant margin and hornblende bearing interior. A gneissic septum separates these two varieties but whether this represents older gneiss or merely a high-strain zone is unclear.

Unassigned Metagabbro, Amphibolite and Mafic Granulite

This variable group of mafic rocks includes fine grained amphibolite, coarse grained garnetiferous amphibolite, two-pyroxene mafic granulite, metagabbro with relict igneous textures and rare melanocratic diorite. Occurrence of the unit vary in size from enclaves within other rock types to the map-scale bodies depicted in Figure 2. The unit was probably derived from mafic intrusions that ranged from minor dikes to small plutons.

Lower Phanerozoic Gabbro, Diorite Dikes.

Three north-northwest trending mafic dikes were mapped in the Paradise River Map

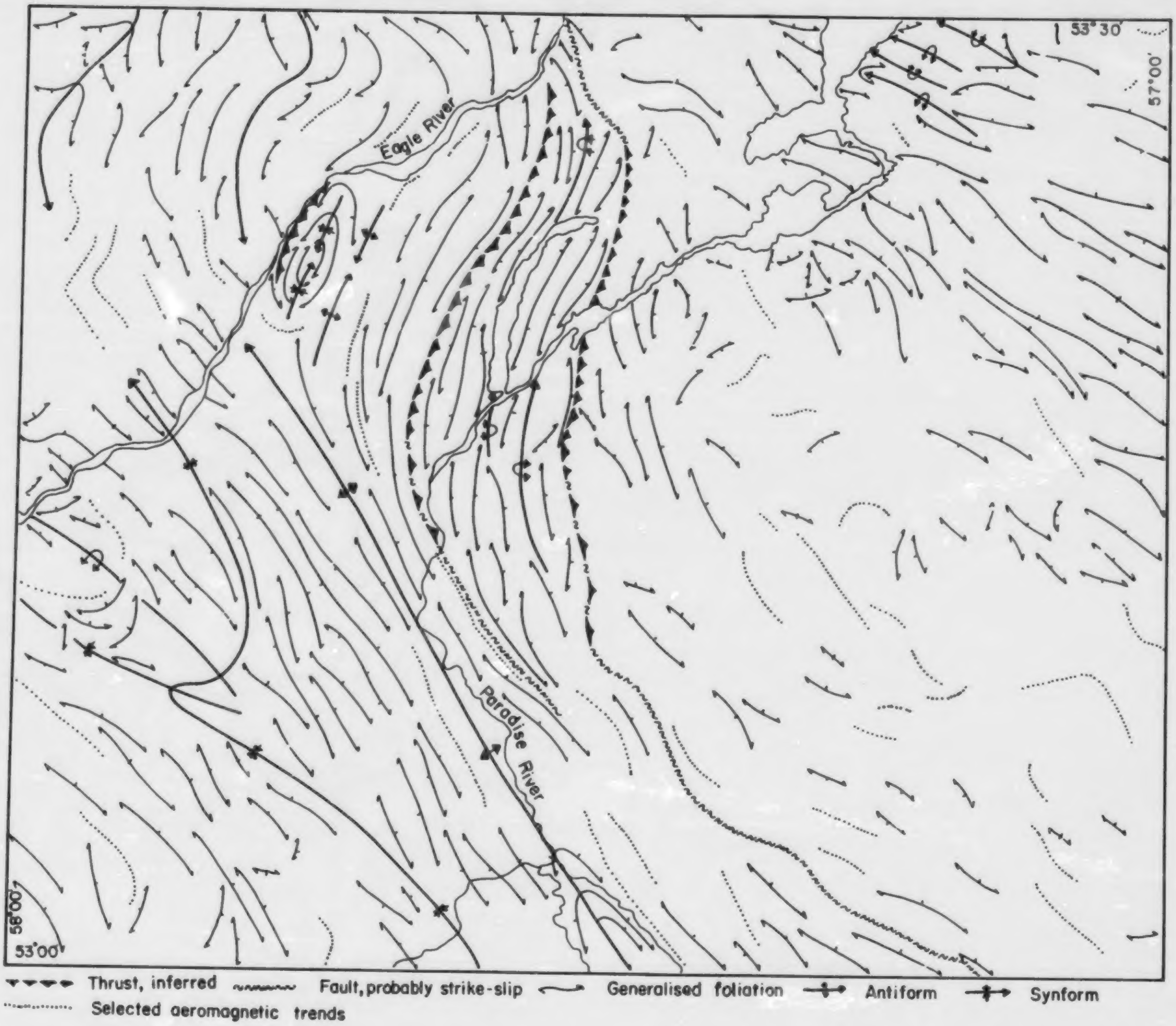

Figure 3: *Generalized foliation trends and other structural features in the Paradise River region.*

area and are extensions to dikes known farther north. The characteristic lithology is a black or brown weathering, coarse grained ophitic-textured gabbro with common interstitial K-feldspar. Typically the mafic silicates have been partially hydrated but primary textures are well-preserved. The westernmost dike extends from north of Cape Porcupine to the south-west quadrant of the map area - a distance of about 100 km. The continuity of the other two dikes is less established but both extend for at least 50 km. K-Ar dates obtained farther north give ages of 514 ± 08 Ma (W.R.) (Grasty et al., 1969) and 553 ± 22 Ma (biotite) (Wanless et al., 1970). These intrusions are correlated with the Long Range dikes of similar trend and age on the Great Northern Peninsula of Newfoundland.

STRUCTURE

For descriptive purposes the region is divided into four northwest-trending sectors. These are, (i) the northeastern area bounded by the southwestern margin of the Paradise Arm megacrystic granodiorite, (ii) the White Bear Arm complex, (iii) the northwestern and central zone, bounded on its southwest side by the unassigned anorthosite unit, and (iv) the southwestern area.

In the northeastern sector regional foliation and gneissosity have a consistent northwest trend (Figure 3). Foliations are steeply dipping (70°) and lineations steeply plunging (50°). Minor folds indicate tight folding, especially in the metasedimentary gneiss; associated lineations define fold axes. The relative dispositions of quartz diorite and metasedimentary gneiss north of Paradise River are interpreted in terms of a regional west-plunging Z fold.

The White Bear Arm complex appears to have a half-basin form. Foliations mostly dip inward (i.e. east or northeast) at angles between 40-70°, although some inward dips of less than 10° were recorded; in the southeast corner, steep outward dips exist. Lineations also plunge radially inward and are interpreted as stretching lineations related to thrusting at the margins of the WBAC. The nature of the thrusting is not known in detail but there are probably several more thrust surfaces present than indicated on Figure 3. Broad zones of mylonite were mapped along Beaver Brook and locally noted elsewhere (Plate 6). Rotated K-feldspar megacrysts indicate that the hanging wall of the thrust has been transported westward. No field evidence for a fault was found between the WBAC and the Paradise Arm pluton despite their linear boundary which appears to truncate regional structural trends in the WBAC.

Plate 6: *Ultramylonite at strike-slip faulting flanking internal thrust.*

The northwest and central zone is characterized by north-northeast structural trends which gradually curve round into a northwest trend in the southern part of the sector. In the vicinity of Crooked Lake, dips are mostly steeply to the east and lineations consistently plunge moderately to the north. Minor folds indicate that lineations are parallel to fold axes and we suspect the presence of tight-to-isoclinal major folds, overturned to the west. The folding becomes more open westward, and the regional plunge changes from north-northeast to southwest, accounting for a basinal structure adjacent to Eagle River. This basin is obvious from photolineaments and is shown on the map of Eade (1962). The isoclinal folds near Crooked Lake are interpreted as the result of west to northwest transport of the WBAC over the underlying gneisses and granitoid plutons.

The unassigned anorthosite which separates the central and western zones has been folded into a shallowly north-plunging antiform. On the northwest side of Eagle River we interpret the antiform axis as swinging north to pass through the circular alkali feldspar granite.

Southwest of the anorthosite, structures revert to a northwest trend with steep foliation dips and moderately plunging, poorly developed lineations. As in the northeast sector, map patterns indicate major Z folds. The large megacrystic granitoid pluton is interpreted to occupy a synform which, northwest of Eagle River, parallels the trend of the adjacent antiform through the anorthosite, and swings north to link up with a well-defined synform in the northwest corner of the study area.

Two post-Grenvillian northeast trending, normal faults, namely the Eagle River and Paradise River faults cross the map area (Figure 4). The faults are accompanied by zones of brecciation and low-grade alteration. The faults link up with similar structures, the Sandwich Bay map-area (Gower et al., 1983a). They define the newly recognized and informally named Sandwich Bay graben, which is probably of similar age to the Double Mer and Lake Melville grabens hosting Double Mer Formation farther northwest. One exposure of similar post-Grenvillian conglomerate was mapped by (Gower et al., 1983a) on the west side of Sandwich Bay.

METAMORPHISM

Metamorphic grade throughout the map area includes upper amphibolite to granulite facies. Garnet is a ubiquitous metamorphic mineral in the orthogneisses and granite plutons and orthopyroxene was observed in several localities in the quartzofeldspathic leucosome of associated mafic rocks. The metasedimentary gneisses are characterized by biotite + sillimanite + garnet + plagioclase - K-feldspar - quartz assemblages. Magnetite is a characteristic accessory phase and muscovite is a locally extensive retrograde mineral. In the northwest continuation of the metasedimentary belt near Paradise River (Gower et al., 1983a) kyanite, orthopyroxene and cordierite have been found in various

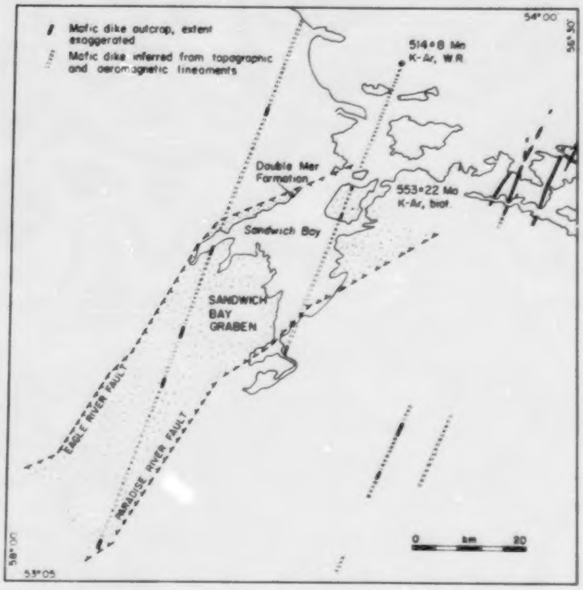

Figure 4: *Distribution of Lower Phanerozoic mafic dikes and outline of the Sandwich Bay graben.*

pelitic assemblages (Gower, unpublished data).

The anorthositic rocks partially retain primary mineralogies but they show extensive hydration to amphibole bearing assemblages and recrystallization of primary silicates. In the White Bear Arm complex primary olivine is preserved as a primary phase mantled by double hypersthene-amphibole coronas. Fine grained granulite is a widespread rock type.

A single K-Ar biotite age of 1105 Ma suggests that temperatures were elevated above 300°C (blocking temperature for biotite) until ca. 1.1 Ga.

REGIONAL STRUCTURAL SYNTHESIS OF THE LAKE MELVILLE TERRANE

Mapping in the Paradise River area, coupled with additional interpretation of previous mapping, allows a preliminary regional structural synthesis of the Lake Melville terrane to be presented here (Figure 5).

The synthesis is based on the premise that there was large-scale regional transport of the Lake Melville terrane in a northwest to north-northwest direction. Thus northeast or east-northeast trending structures are either thrust slices or overturned isoclinal folds in contrast to northwest trending structures which are essentially right-lateral strike-slip faults, with a possible thrust component. Although the east-northeast trending margin of the Lake Melville terrane has been markedly modified by post-Grenvillian normal faults related to the formation of the Double Mer graben, one thrust lobe is preserved north of the graben in the Double Mer White Hills. This lobe has well-developed, shallowly south-plunging stretching lineations. Because of lithological and metamorphic contrasts with the surrounding rocks this lobe is taken as the boundary of the Lake Melville terrane. However the thrust slice is one of a package - some thrusts cross the southern Groswater Bay terrane - and there is evidence of structural repetition within the Double Mer White Hills thrust lobe.

The Double Mer White Hills lobe is one of several thrust sheets that occur across the Grenville Province of Labrador, as well as farther west. The Cape Caribou River allochthon (Ryan et al., 1982; Wardle and Ash, 1984), north of Goose Bay (Figure 1) is comparable to the Double Mer White Hills thrust sheet in lithological make-up, structural style and metamorphic grade. Larger allochthons farther west include the Wilson Lake and Lac Joseph allochthons (Figure 1).

Southeast of Rigolet, the northern boundary of the Lake Melville terrane has a regional northwest trend, which continues to the southeast Labrador coast (Figure 1). Most foliations dip steeply southwest along this section of the boundary, except near Rigolet where, as the regional trend changes to east-northeast, foliations are less steep and south plunging lineations are obvious. We suggest that the northwest trending part of the Lake Melville terrane boundary is a major right-lateral strike-slip fault and that there are many similar faults within the southeast Lake Melville terrane.

The English River fault bounding the northeastern side of the Mealy Mountains Intrusive Suite is interpreted as major right-lateral strike-slip fault. Sense of movement is based on limited observations in the English River area. This passes through the Paradise River as a diffuse zone of ductile deformation in the region of the unassigned anorthosite. The combined effect of movement along the English River fault and movement along the northeastern boundary of the Lake Melville terrane is to slice up the intervening region into a series of blocks with internal northwest facing, frontal thrusts and flanked by strike-slip faults.

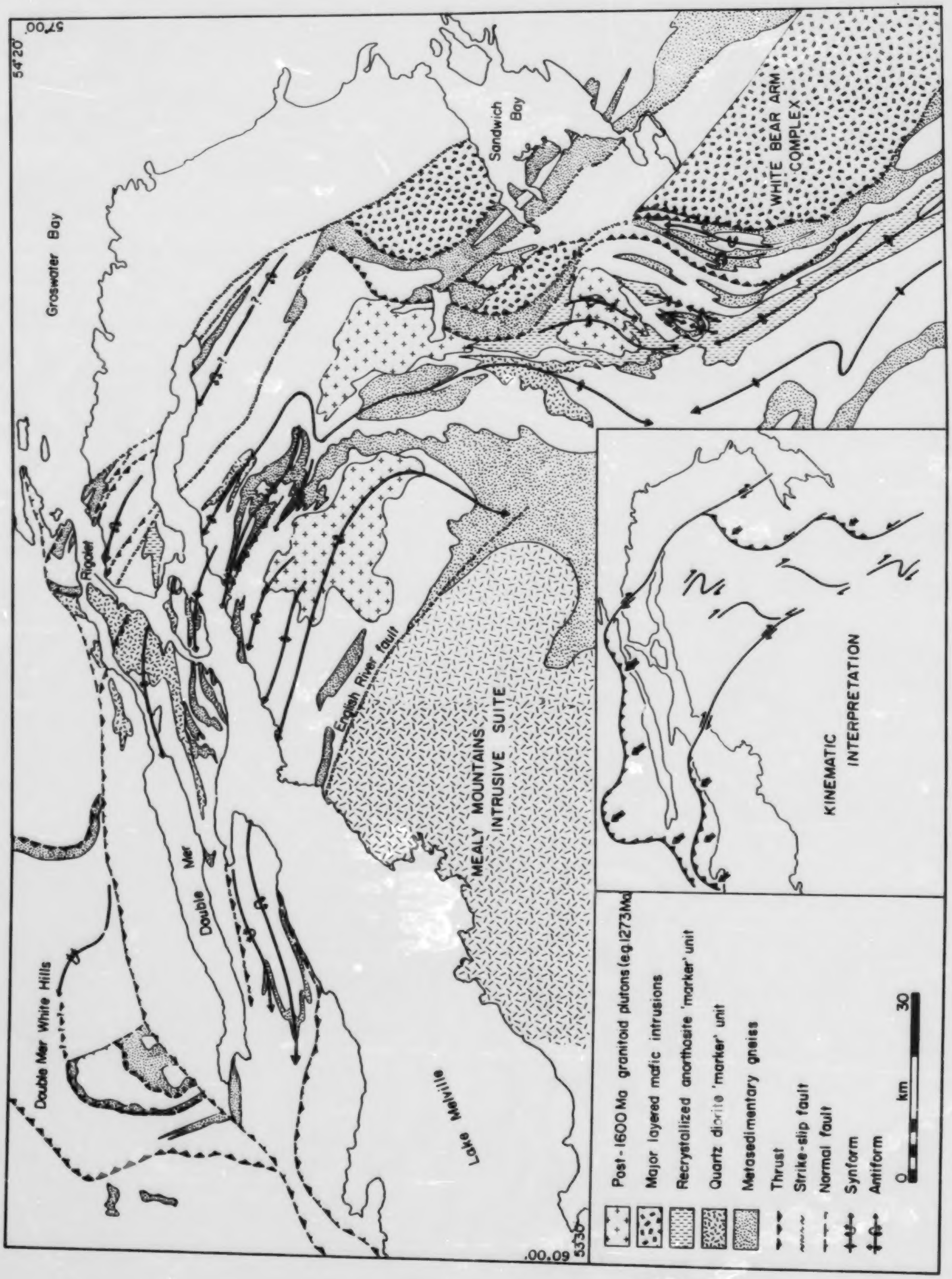

Figure 5: *Regional geological synthesis of the Lake Melville terrane.*

Structurally underlying these 'internal' thrusts the rocks have been deformed into isoclinal, overturned northwest verging folds which, away from the thrust front become more open. The folds more distant from the internal thrusts are major regional structures which are unlikely to have a direct causal link with the thrusts.

Several major folds have been interpreted to occur between Eagle River and the Mealy Mountains. An antiform northwest of Eagle River is outlined by unassigned anorthosite and the core of the fold has been intruded by alkali feldspar granite. The synform farther west has been interpreted to extend from the southern boundary of the Paradise River area to west of Rigolet, a distance of approximately 150 km. The axial trace of the synform is defined by folded quartz diorite bodies in places. The antiform west and south of the synform is actually a domal structure outlined by metasedimentary gneiss. The core of this dome has been intruded by a clinopyroxene bearing quartz syenite to granite which gives a 1273 Ma (U-Pb zircon) age (Krogh, personal communication 1984). We suspect a similar age applies to the alkali-feldspar granite intruding the antiform near Eagle River.

The effect of northwest transport of the Mealy Mountains terrane has been to tighten the northwest end of the domal structure (north of Lake Melville) into a series of tight, overturned, north verging folds and to refold the regional synform in the Paradise River region into open Z structures.

ECONOMIC MINERAL POTENTIAL

The economic mineral potential of the area was assessed during reconnaissance surveys by British Newfoundland Corporation Ltd. (BRINCO), the results of which did not encourage continued activity. However, subsequent more comprehensive aeromagnetic coverage, as well as more detailed geological mapping and results from regional lake sediment surveys suggests, to us, that the area deserves reassessment.

Metasedimentary gneiss appears to be a unit with some economic potential (see Gower and Erdmer, 1984). Sulfide rich zones (mainly pyrite, but with minor chalcopyrite) are common especially in the metasedimentary gniess belts through Crooked Lake and 8 km west of Crooked Lake. Anomalously radioactive pegmatite (counts up to 20 times background) was discovered on the west side of Crooked Lake. The metasedimentary gneiss in the Crooked Lake region also hosts an abandoned mica quarry with biotite and muscovite books 15-20 cm in diameter.

Another major feature of potential economic interest is a granite in the northwest part of the map area. This has anomalous radioactivity, in one place reaching 20 times background, and may be a host to other lithophile element mineralization.

Lake sediment geochemical anomalies (especially U in water) are closely associated with this granite.

Other economic possibilities include Ni-Co-Cr-Cu mineralization within the White Bear Arm complex and LIL element mineralization in various pegmatiates associated with some of the K-rich megacrystic granitoid plutons.

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NAIN-CHURCHILL PROVINCE BOUNDARY: A PRELIMINARY REPORT ON A CROSS-SECTION THROUGH THE HUDSONIAN FRONT IN THE SAGLEK FIORD AREA, NORTHERN LABRADOR

by

F. Mengel*

ABSTRACT

The lower Proterozoic Ramah Group occurs as a north trending fold belt between Nachvak and Hebron Fiords in northern Labrador.

This paper presents the results of an investigation of deformation and metamorphism of the Ramah Group and adjacent gneisses in the area between Saglek Fiord and Lake Kiki.

The Ramah Group overlies the junction between the Nain and Churchill Provinces. The Churchill Province, to the west, comprises chiefly Archean rocks reworked, together with Ramah Groups rocks, during the Hudsonian orogeny, whereas Archean gneisses of the Nain Province, to the east, are only slightly affected by the Hudsonian orogeny. Prior to the Hudsonian orogeny, the Archean basement was intruded by a lower Proterozoic east-west trending dike swarm.

The original Hudsonian metamorphic zonation has been significantly telescoped along a system of west-dipping thrust faults that can be recognized in the Churchill as well as the Nain Province. In the Ramah Group, Hudsonian metamorphism varies from lower greenschist to amphibolite facies assemblages. In the Nain Province, Hudsonian effects are recognizable immediately east of the Ramah Group, and occur as retrogression of gneisses and greenschist to lower amphibolite facies metamorphism of lower Proterozoic dikes.

During the Hudsonian orogeny, movements along north-south trending sinistral shear zones caused significant rotation of lower Proterozoic dikes in the Churchill Province. Easterly directed thrusting evidenced by numerous west-dipping mylonite and pseudotachylyte zones succeeded the transcurrent movements and brought granulite over amphibolite facies rocks.

The dominant Hudsonian structures in the Saglek Fiord region are north-northwest trending west-dipping planar fabrics and gently north-northwest plunging mineral lineations. Orthopyroxene with this orientation shows that granulite facies conditions in places accompanied Hudsonian deformation. Significant telescoping of the metamorphic zonation indicates that phases of Hudsonian deformation postdate the peak of metamorphism.

A regional tectonic model is suggested. This is in accord with the pattern of late Archean-Proterozoic deformation in eastern Labrador as well as in southern Greenland.

INTRODUCTION

This report presents some preliminary results of field work across the Nain-Churchill Province boundary in the Saglek area. Work was carried out in two areas (Figure 1): the northern area around Lake Kiki provided information about the Ramah Group and the reworked Archean gneisses immediately west of the Ramah Group, and the southern area, along Saglek Fiord, gave insights into the section through the Ramah Group and gneisses on both sides.

The study aims at establishing the north-south and east-west gradients of Hudsonian metamorphism and deformation as monitored by rocks of the Ramah Group and the adjacent gneisses.

GEOLOGICAL SETTING

The Lower Proterozoic Group is predominantly of sedimentary origin (Morgan, 1975; Knight and Morgan, 1981) and occurs as a north trending fold belt between Nachvak and Hebron Fiords in northern Labrador (Figure 1).

Along its eastern margin, the Ramah Group is in unconformable contact with Archean gneisses of the Nain Province; these gneisses have had a long and complex pre-Ramah history (e.g. Morgan, 1975; Bridgwater et al., 1975; Collerson et al.,

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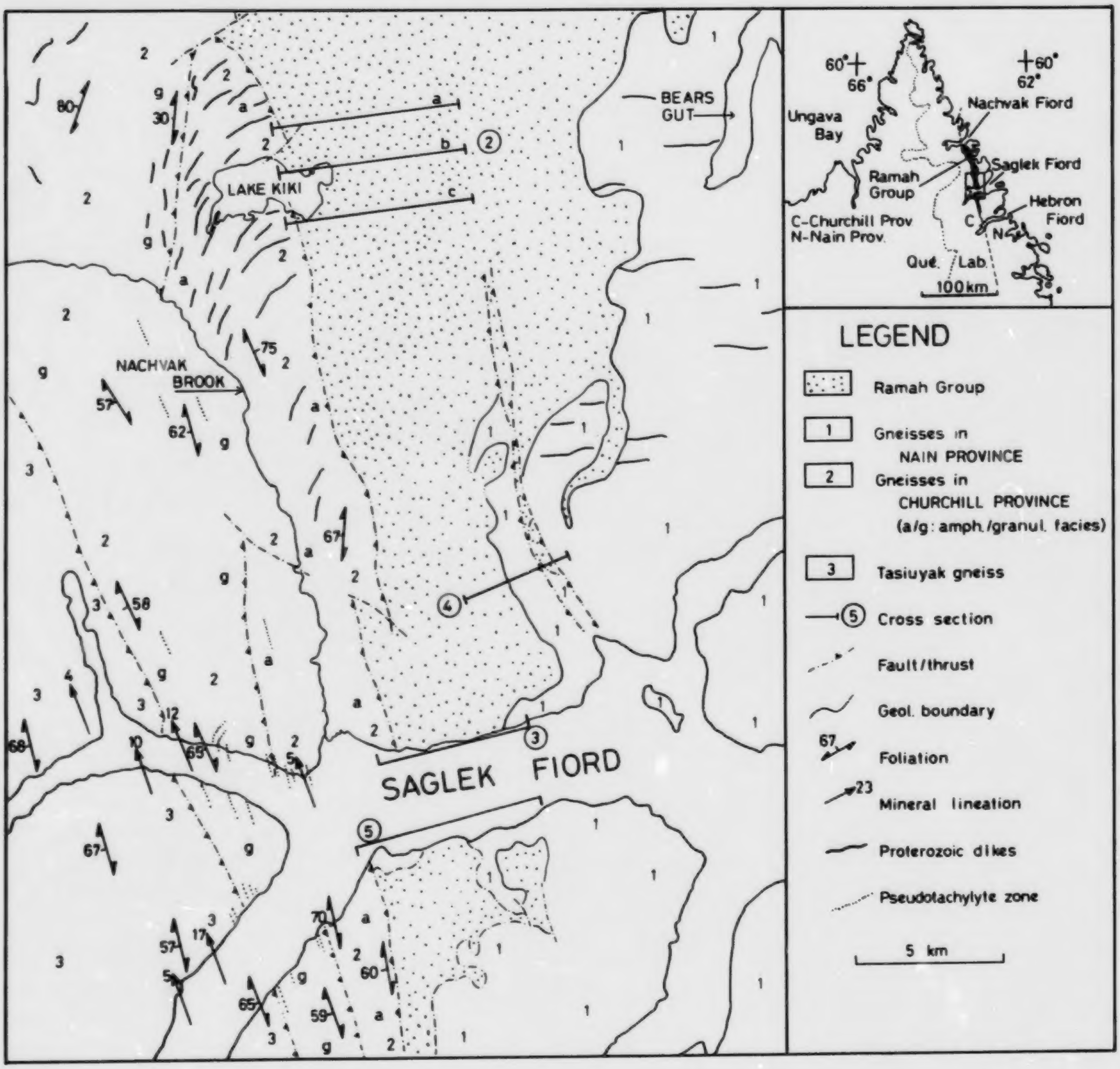

Figure 1: *Index map to the study area with generalized geology. Dikes, pseudotachylytes, etc. are mainly indicated where studied. Numbers refer to Figure number of cross-sections. Incorporates data from Morgan (1975, 1978) and Ryan et al. (1983).*

1976; Collerson and Bridgwater, 1979; Ryan et al., 1983, 1984).

Gneisses west of the Ramah Group belong to the Churchill Province, and are in tectonic contact with the Lower Proterozoic metasediments. Churchill Province gneisses are chiefly Archean rocks overprinted and reworked during the Hudsonian orogeny. The Ramah Group was variably deformed and metamorphosed during the Hudsonian, and increasing metamorphism and structural complexity have been reported from east to west and from north to south (Morgan, 1975; Ryan et al., 1983, 1984; Mengel, 1984).

DESCRIPTION OF ROCK UNITS

Nain Province, east of the Ramah Group

The Archean basement comprises a complex unit predominantly composed of banded quartzofeldspathic gneisses of tonalitic to granodioritic composition, and includes remnants of two supracrustal sequences and a number of discrete plutonic units. The grade of metamorphism is upper amphibolite to granulite facies. The basement gneisses are intruded by a predominantly east-west trending Early Proterozoic dike swarm dated at 2300-2400 Ma (Fahrig, 1970; Taylor, 1974). During the Hudsonian Orogeny, the dikes in the westernmost part of the Nain Province were converted to amphibolites, but discordances are preserved.

The unconformity at the base of the Ramah Group is marked by a regolith (average thickness 1-8 m, maximum 12 m; Knight and Morgan, 1981). In the regolith feldspars from the Archean gneisses are thoroughly altered to greenish gray clay minerals, whereas quartz, although slightly bleached, is otherwise unaltered. Structures in the regolith perfectly outline the original gneissic layering.

Where the Ramah/basement contact has not been reactivated by thrusting, the main cleavage in the Ramah rocks can be traced without interruption into the regolith. However, thrusting has obliterated the regolith in many places (e.g. south of Saglek Fiord; Morgan, 1975; Ryan et al., 1983; Mengel, 1984).

Churchill Province, west of Ramah Group

Gneisses of the Churchill Province are comparable to those of the Nain Province, but have experienced additional metamorphism and deformation during the Hudsonian orogeny. Archean structures dominate gneisses immediately west of the Ramah Group, but farther west the north-northwest oriented 'Hudsonian trend' gradually obliterates all earlier fabrics. South of Saglek Fiord, however, all gneisses west of the Ramah Group have strong Hudsonian fabrics, and the gradual transition observed farther north is not seen. Gneisses west of the Ramah Group (marked 2a on Figure 1) underwent Hudsonian amphibolite facies metamorphism, but still contain relics of earlier (Archean) granulite-facies assemblages. Hudsonian amphibolite-facies gneisses are separated from Hudsonian granulite-facies gneisses further west (2g on Figure 1) by a major north-northwest trending west-dipping thrust fault (e.g. just west of Lake Kiki, Figure 1).

North-south trending, west-dipping mylonite zones and networks of pseudotachylyte veins occur throughout the gneisses in the traversed part of the Churchill Province. Along the north shore of Saglek Fiord, the pseudotachylyte/ mylonite zone separating granulite from amphibolite facies gneisses is at least 100 m thick, and zones of comparable thickness and orientation occur further west towards and within unit 3 (the Tasiuyak gneiss, see Figure 1). Similar zones occur south of Saglek Fiord (B. Ryan, personal communication), and are shown on Figure 1.

Tasiuyak gneiss

The Tasiuyak gneiss, named by Wardle (1983), is a pervasively lineated quartzofeldspathic garnet-biotite (± sillimanite, ± graphite) gneiss with highly attenuated quartz stringers, locally seen to be folded in millimetre-scale isoclinal folds. Pre-, syn-, and postkinematic garnet occur, and cordierite has been observed locally in hand specimen. The Tasiuyak gneiss contains layers, in some places isoclinally folded, of rusty metasediments and garnet-bearing mafic and ultramafic granulites (Wardle, 1983, 1984; Ryan et al., 1983, 1984).

Leucosomes, which define the prominent linear microstructures in the rock, are tonalitic to granodioritic in composition. The origin of the unit is somewhat enigmatic; Wardle (1983) considers it to be a diatexite, perhaps combined with thorough leucogranite injection, of an aluminous Archean sedimentary protolith. Ryan et al. (1983, 1984) suggest a similar origin, and report evidence of Tasiuyak gneiss intruding neighboring rocks in support of extensive anatexis within the unit.

Ramah Group

The lower four of the six formations constituting the Ramah Group (Morgan, 1975; Knight and Morgan, 1981) are represented in the mapped areas. Immediately overlying the regolith, the Rowsell Harbour Formation comprises quartzites and minor pelites and dolostones. The Reddick Bight Formation contains characteristic fine grained laminites as well as quartzites, pelites and minor dolostone. These two formations represent shallow shelf sedimentation, whereas black graphitic and pyritiferous shales of the overlying Nullataktok Formation are interpreted to indicate rapid subsidence with subsequent deep-water sedimentation. In the area north-east of Lake Kiki, dolomitic rocks of the Warspite Formation occur. The members of this formation are deepwater fan deposits derived from a silicic/carbonate shelf environment.

The lower three formations of the Ramah Group are intruded by diabase sills.

STRUCTURE

Preliminary cross-sections have been constructed in what are considered to be key areas in order to demonstrate the important elements of the structural geology of the Hudsonian front (Figures 2, 3, 4, and 5).

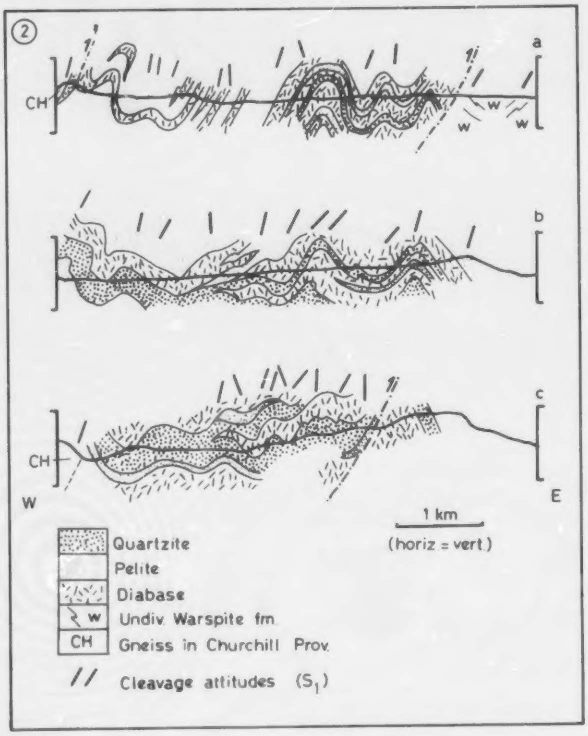

Figure 2: *Cross-sections in Ramah Group east of Lake Kiki. For location of sections, see Figure 1.*

Lake Kiki cross-section: Figure 2 shows three cross-sections in the Ramah Group east of Lake Kiki. Folds are generally open, and fold axes are everywhere gently (10-30°) north to north-northwest plunging with axial planes slightly overturned to the east. S_0 is a compositional or laminar bedding, and S_1 is a slaty to phyllitic cleavage in pelitic rocks and a coarser fracture cleavage in quartz-rich rocks and diabase sills. S_0-S_1 relationships are generally well preserved, and only rarely is S_0 obliterated.

Younging criteria (cross-bedding) indicate that all units are the right way up. These cross-sections show, as also noted by Morgan (1975), the radial fanning of cleavage where the more competent diabase sills are involved in folding. Locally, the effects of a later deformation episode (D_2 - more or less coaxial with D_1) can be seen as minor crenulations of S_1. Preliminary observations suggest that D_2 is better developed in the western part of the Ramah Group. The transgressive nature and frequent wedging-out of the diabase sills is also evident from the cross-sections. These characteristics, combined with shallow-plunging fold axes and gently rolling topography, give a complex outcrop pattern in map view. Towards the western contact, folds in the Ramah Group become more overturned to the east, and more asymmetrical (Figure 2, sections a and b). This is probably caused by Churchill gneisses being thrust eastwards over Ramah Group rocks.

Northern side of Saglek Fiord cross-section: This section (Figure 3), along the north shore of Saglek Fiord, represents a superbly exposed cut through both the Ramah Group and the stratigraphically underlying gneisses. Ramah Group rocks are gently folded in open folds and face upward everywhere. East-directed thrusting is evident in several places. In the central part of the section adjacent east- and west-dipping thrusts (backthrusts) combine to form a prominent 'pop-up' structure. In the eastern part, the boundary between the Ramah Group and the gneisses of the Nain Province is gently dipping and represented by a well-preserved regolith.

In the west, however, the boundary between the Ramah Group and the gneisses of the Churchill Province is vertical to steeply east-dipping, and the regolith is not observed. The orientation of this boundary could have resulted from folding related to east-directed thrusting, or could be the site of a reverse fault with limited displacement. The latter suggestion is favored because the corresponding contact south of Saglek Fiord is a back-thrust, based on observations of asymmetric folds and truncated structures (see below).

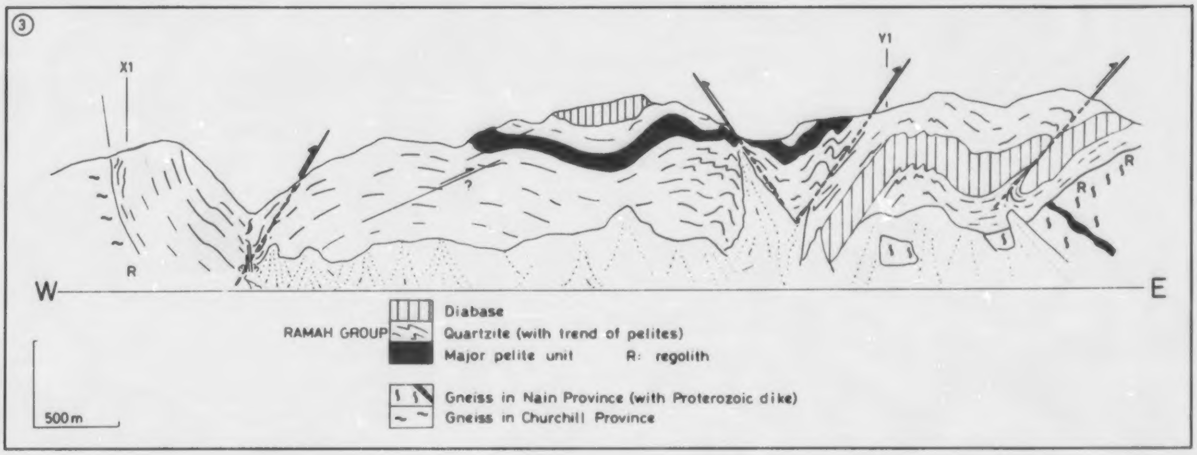
③
X1
Y1
R
?
W
E
RAMAH GROUP
Diabase
Quartzite (with trend of pelites)
Major pelite unit
R: regolith
Gneiss in Nain Province (with Proterozoic dike)
Gneiss in Churchill Province
500m

Figure 3: *Schematic cross/cliff-section in Ramah Group and adjacent gneisses along the north shore of Saglek Fiord, based on observations from the fiord and visits to accessible outcrops. Scale approximate. X1 and Y1 are reference points for comparison with Figure 5.*

A certain amount of backthrusting is also considered necessary to explain the fanning of cleavage observed in the Ramah Group. S_1 dips eastward in the western part of Figure 3 and westward in the eastern part. East of Figure 3 (see also Figure 4a), the fan swings back to an easterly dip. Backthrusting is also thought to be responsible for this local fanning (see discussion below).

Figure 3 also demonstrates the different rheological behaviour during deformation of competent diabase sills as opposed to less competent pelites. Diabase responds to compressive stress by large scale open folding and faulting, whereas pelites become more highly contorted and thoroughly folded in smaller scale open to tight folds, and locally exhibit considerable thickening in axial zones. The style of folding is thus dominantly controlled by the more competent units.

Easterly Ramah Group cross-section: The nature of the eastern margin of the Ramah Group is further exemplified in Figure 4 which is a cross-section about 5 km north of Figure 3 (see Figure 1 for location). Here, the Ramah/basement boundary does not mark a zone of dislocation and the steeply west-dipping cleavage in Ramah Group rocks penetrates into the underlying regolith. The boundary between gneisses and the 'outliers' of Ramah Group rocks to the east is not exposed, but considering field observations, the present distribution of rock units can be explained in two ways: in figure 4b, the configuration is interpreted in terms of a folded thrust-surface, and in Figure 4c as a series of synclinal 'pockets' preserved between two thrusts and a backthrust. At present, several observations favor the latter model:

(a) The prominent fanning of the cleavage is more likely related to the various thrusts than to a single fold phase.

(b) If folding of a thrust-surface was involved, one would expect to find evidence of fabrics related to the thrusting as well as to the subsequent folding. However, this is not the case and, instead, very simple S_0-S_1 relationships and a well-preserved regolith are preserved.

(c) Extensions of what appear to be the faults/thrusts suggested in Figure 4a have been observed both north (10-15 km) and south (2-3 km) of the section (Morgan, 1978).

(d) Possible thrusts occur to the east in Archean gneisses in the Nain Province (B. Ryan, A. Nutman; personal communication).

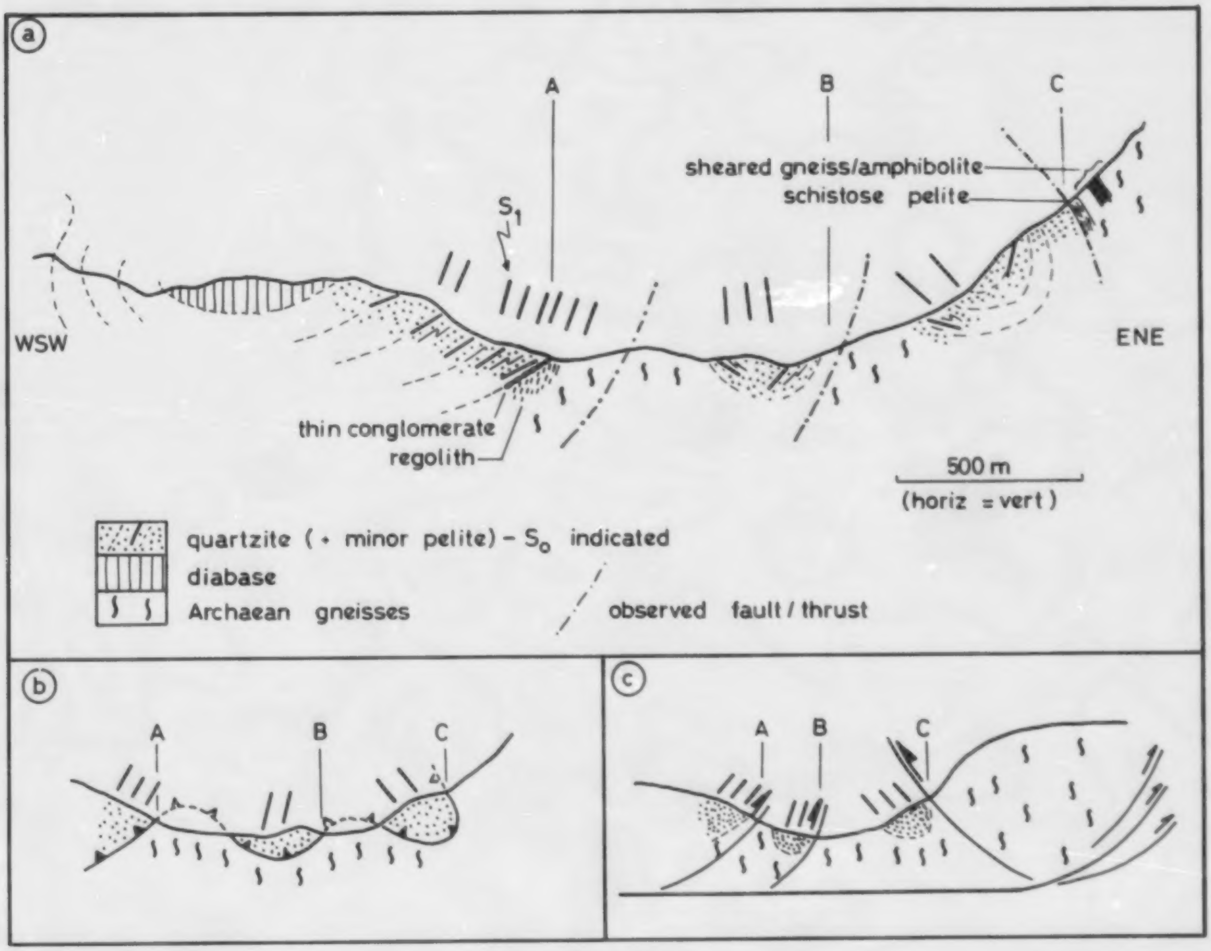

Figure 4: *(4a): Cross-section in the eastern Ramah Group and underlying Archean gneisses.*
(4b): Schematic interpretation of (4a) in terms of a folded thrust-surface.
(4c): Schematic interpretation of (4a) in terms of a combination of thrusts and backthrusts.
(because A, B and C occur in all 3 figures) A, B, and C are reference points.

South side of Saglek Fiord cross-section: The section along the south shore of Saglek Fiord (Figure 5) shows a slightly different pattern from that on the north shore. In this section, only a few east-directed, west-dipping thrusts are seen, whereas backthrusts of the opposite sense are more common.

Assuming a generally compressive tectonic regime created by east-directed forces, these backthrusts probably formed in response to large stress build-ups in the gneisses east of the Ramah Group. A number of less conspicuous west-dipping thrusts with minor displacements may well occur in the Ramah Group, as indicated by mapping further south of Saglek Fiord (Mengel, 1984), and these may together account for significant shortening.

The westernmost thrust fault is not fully understood at present. The distribution of rock units indicates a normal fault with 'west-side-down' movement, but asymmetric folds suggest the opposite sense of movement, which would be compatible with east-directed thrusting. Normal faulting, on the other hand, should be associated with extension in an east-west direction, for which no evidence has been encountered yet. Alternatively, the Ramah Group rocks

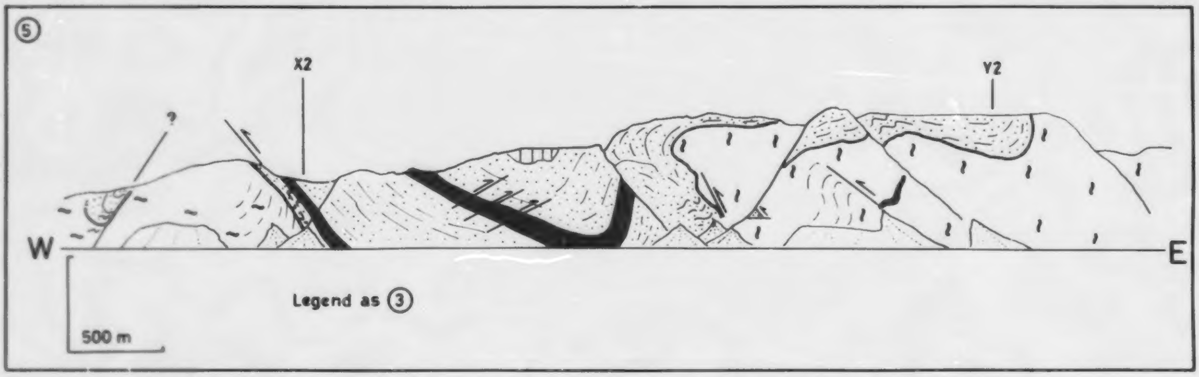

Figure 5: *Schematic cross/cliff-section of Ramah Group and adjacent gneisses along south shore of Saglek Fiord. East and west have been inverted for ease of comparison with other sections. Based on observations from the fiord and visits to outcrops along the shore. Section drawn from photographs, so in the eastern third the perspective is slightly distorted. What looks like a major basement-cored west-verging fold is a generally west-dipping Ramah/basement boundary. Scale approximate. Legend as Figure 3. X2 and Y2 are reference points for comparison with Figure 3.*

could constitute a synclinal 'pocket' between two thrusts, similar to the configuration shown in Figure 4.

Structural continuity from south to north

The reference points X1 and Y1 in Figure 3 have been extrapolated across Saglek Fiord (X2 and Y2 in Figure 5) along lines parallel to the axial surfaces of large scale folds in the Ramah Group. It is obvious that the distribution of thrusts, backthrusts, anticlines and synclines varies along the length of the Ramah Group. If, furthermore, Figures 3 and 5 are compared with Figure 2, the picture of north-south variations becomes even more evident.

An important consequence of the configuration of thrusts and backthrusts in the above cross-sections is that the entire Ramah Group must be underlain by a basal thrust. Such a thrust, probably located in the basement, is the only way the shortening evidenced by the thrusts seen at the surface, can be geometrically accommodated. The north-south variations are thus a reflection of where and how thrusts cut up-section from the basal thrust (i.e. distribution of ramps in the basement) and of the amount of stress build-up in the gneisses (space problem) giving rise to backthrusting. The amount of displacement on the observed thrusts in the Ramah Group is probably not large, as shown for example by the high degree of lithological continuity. Taking 30% as the shortening necessary for the initiation of cleavage formation, the amount of postdepositional shortening of the Ramah Group must be in the order of 30-50%.

In the gneisses, on the other side, the amount of displacement is harder to assess. The thrust bringing granulite-facies gneisses over amphibolite-facies gneisses could be the site of considerable dislocation.

Structure west of the Ramah Group

The gneisses in the Churchill Province have been examined in detail along sections immediately west of the Ramah Group (1-2 km north of Figure 3). Archean structures are generally overprinted by north to north-northwest trending moderately west-dipping Hudsonian planar fabrics, or are truncated by similarly oriented mylonite zones, shear zones, and brittle/ductile fault zones. Small scale folds have a constant vergence, all indicating easterly directed tectonic transport. Characteristic of these shear zones is a reddish color of the tonalitic/granodioritic gneisses. Proterozoic dikes are converted to amphibolites, and display brittle faulting (dextral offset, looking north) parallel to the shear zones. Towards the Churchill/Ramah contact, Archean linear fabrics change from northwest to southwest plunging, probably reflecting rotation into parallelism with the direction of tectonic transport combined with the brittle conjugate folds mentioned above, suggest that uplift accompanied later stages of Hudsonian deformation. The mineralogy of these later brittle zones indicates greenschist facies conditions, thus suggesting that the kinematic phase postdates the main Hudsonian metamorphism.

Planar and linear fabrics of gneisses in the Churchill Province (especially in units 2g and 3 in Figure 1) are uniform, and are attributed to Hudsonian tectonism. Mineral lineations are everywhere gently north-northwest plunging, and the observation of othopyroxene grains aligned parallel to this direction indicates that granulite facies conditions in places accompanied Hudsonian tectonism. The stability of orthopyroxene by definition indicates granulite facies conditions, but temperature, pressure and fluid activity may have varied siginificantly from Archean to Proterozoic granulite facies metamorphism. The prominent 'Hudsonian trend' is believed to be related to transcurrent movements along the Hudsonian front. The (re)orientation of the Proterozoic dikes provide information on the timing and sense of movement (see below).

PROTEROZOIC DIKES

In the Nain Province, the Proterozoic dike swarm is generally east-west trending (e.g. Morgan, 1975, 1978; Ryan et al., 1983, 1984). Figure 1 shows selected dikes east and west of the Ramah Group. Immediately east of the Ramah Group, the dikes have been affected by Hudsonian metamorphism and deformation, and are converted to amphibolites with a variably developed schistosity. West of the Ramah Group, dikes have a stronger Hudsonian overprint. Within the amphibolite facies gneisses (unit 2a in Figure 1), the dikes are amphibolites and they are rotated into (near) parallelism with the gneissic foliation. Further west in granulite facies gneisses (unit 2g in Figure 1), the dikes are garnet-two pyroxene-bearing mafic granulites.

The thrust fault separating the granulite-facies gneisses from the amphibolite-facies gneisses also records changes in the style of dike deformation. Within the amphibolite-facies block, the dikes are systematically rotated anticlockwise from east-west to north-south orientation as one moves west from the Churchill/Ramah contact (Figure 1). In the granulite facies block, on the other hand, the dikes appear less strongly deformed and reoriented, and discordances are frequently observed. This, together with the prominent subhorizontal lineation of the 'Hudsonian trend', suggests that early sinistral transcurrent movements occurred along the Hudsonian Front, and these were succeeded by thrusting and easterly transport of granulite-facies rocks that were less affected by the earlier transcurrent movements.

METAMORPHISM

Based on field observations, the metamorphic grade in Ramah Group rocks varies only slightly (greenschist to lower amphibolite facies) in the areas studied. Generally, biotite is not present, and quartz and carbonate coexist stably. Chloritoid, sometimes with kyanite, appears in rocks of appropriate composition in both western and eastern parts of the Ramah Group. Higher grade kyanite-bearing schists occur along the western margin. Lithological discontinuities suggest that these units are thrust slices brought up from slightly deeper levels.

West of the Ramah Group, Hudsonian metamorphism increases. Amphibolite facies overprinted Archean granulite-facies assemblages in unit 2a (Figure 1) and further west (unit 2g) granulite-facies conditions prevailed. Thorough syntectonic recrystallization obliterated evidence of the pre-Hudsonian (Archean) mineral assemblages in unit 2g, but considering the overall similarities between the units 2a and 2g, 2g was probably also affected by granulite facies metamorphism in the Archean.

The distance between Hudsonian granulite-facies assemblages in the west and greenschist-facies rocks in the east is less than 8 km (see Figure 1). Movement on the observed thrusts and mylonite zones must have caused substantial telescoping of the original Hudsonian metamorphic zonation. A similar shortening was observed south of Saglek Fiord (Mengel, 1984).

Orthopyroxenes oriented parallel to the Hudsonian linear trend show that granulite-facies conditions accompanied Hudsonian strike-slip deformation, and the telescoped metamorphic zonation suggests that phases of the east-directed thrusting clearly postdated peak metamorphism in the reworked basement.

DISCUSSION

Observations of transcurrent movements and thrusting in the Churchill Province are in excellent agreement with the indentation model of Watterson (1978) to explain the large scale tectonic features of Proterozoic mobile belts of Greenland. This model (Figure 6) explains the distribution of deformation across the Archean/Protero-zoic boundary in Greenland in terms of a rigid 'indenter' pressing north across southern Greenland. As a result, north-south to northeast-southwest trending sinistral shear zones, as well as southeast-directed thrusting, will occur in western Greenland and areas immediately west thereof (e.g. northeastern Labrador).

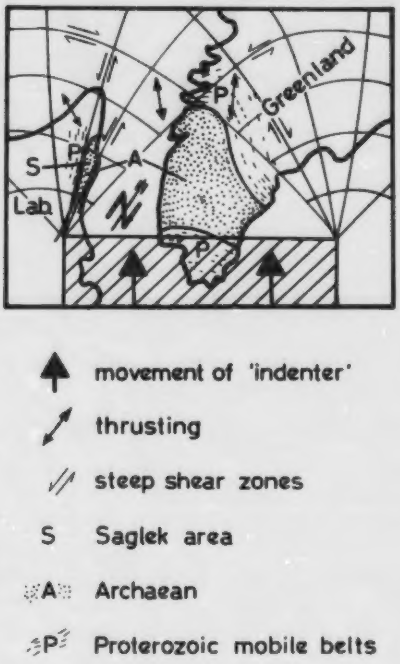

Figure 6: *Indentation model of Watterson (1978) to explain Late Archean-Proterozoic deformation in Greenland. The indenter sets up a large scale stress-system (thin lines) that is predicted to form shear zones and thrusts (arrows indicate sense of shear and direction of thrusting). Location of Labrador with respect to Greenland from Collerson et al. (1976).*

The suggested sinistral transcurrent shear and the east-directed thrusting in the Saglek Fiord area are in accord with the above model, and can be interpreted in terms of collision-type tectonics succeeding the intracratonic deposition of the Ramah Group.

ACKNOWLEDGEMENTS

This project is funded by Aarhus University, Denmark; and NSERC. Critical reviews by Bruce Ryan, Dick Wardle, Toby Rivers, and Allen Nutman substantially improved the manuscript. Toby Rivers is thanked for encouragement and enthusiastic help and advice during the ten most interesting days in the season. Assistant Kevin Staples admirably coped with the problems of a strenous but eventful summer. Wayne Tuttle and Ken O'Quinn provided efficient logistic support. All help is gratefully acknowledged.

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THE LABRADORIAN OROGENY: GEOCHRONOLOGICAL DATABASE[1]

by

G.A.G. Nunn, A. Thomas and T.E. Krogh[2]

ABSTRACT

The Labradorian Orogeny is defined as the deformation and metamorphism of Aphebian sedimentary rocks and the associated emplacement of a granitoid batholith and other plutonic suites that occurred in southern Labrador between 1700 and 1600 Ma. The orogeny is documented here from south-central and southwestern Labrador but its effects may also extend eastwards to the coast of Labrador. Prebatholith (early Labradorian) metamorphism ranged in grade from upper amphibolite to granulite facies and locally resulted in development of the assemblage hypersthene + sillimanite + quartz ± sapphirine ± cordierite. Geochronological data constrains the prebatholith dynamothermal events between 1680 and 1650 Ma. The regional metamorphism was followed by the emplacement of the Trans-Labrador batholith at circa 1655-1650 Ma. The batholith joins together crustal areas in the south, that were affected by the early Labradorian events, to crust in the north that was apparently stabilized during the Hudsonian Orogeny (circa 1800 Ma) and which is not yet known to have been affected by the early Labradorian deformations. A charnockite-gabbronorite association that is present within granulite facies terranes is considered to be the deep crustal equivalents of the batholith. Further high-grade events followed the plutonism in the south, and greenschist facies foliations were imposed on the batholith in the north. The postbatholith events range from late Labradorian (1650-1600 Ma) to Grenvillian (circa 1000 Ma) in age. The area has been variably reworked during the Grenvillian Orogeny and now lies within the northern part of the Grenville Province.

INTRODUCTION

1:100,000 scale mapping (Figure 2), undertaken by the Newfoundland Department of Mines and Energy and the Geological Survey of Canada since 1977, has allowed a new geological compilation of central and western Labrador (Figure 1). A recent geochronological program, within the same region, has revealed the existence of extensive areas that are underlain by pre-Grenvillian gneisses and a granitoid batholith, both of which are 1700-1600 Ma in age. Throughout the area, the late Lower Proterozoic spatial relationships have been modified or obscured by tectonic events of Grenvillian age, during which the rocks were stacked into a series of thrust-separated blocks. The tectonic zonation of the northern part of the Grenville Province that is related to this thrusting is shown in Figure 2.

LABRADORIAN OROGENY[3]

The geochronological program has given numerous dates in the range from 1685 Ma to 1600 Ma.The methods used include U-Pb concordia and discordia dates on zircon, sphene, apatite and monazite, Rb-Sr whole rock isochrons and errochrons, and Ar-Ar hornblende plateau ages. These dates all occur within the northern part of the Grenville Province and come mostly from foliated to gneissic granitoid rocks and high-grade paragneisses. The abundance of 1700-1600 Ma dates and the variety of methods involved suggest that they represent a significant geological event. This has been termed the Labradorian Orogeny (Nunn, Noel and Culshaw, 1984) and the affected area the Labrador Orogen (Thomas, Nunn and Wardle, in press). The orogeny is defined largely on geochronological grounds and a precise separation of the associated structural and metamorphic features from those of earlier or later events is not yet possible.

The orogen is characterized by paragneiss and granitoid plutonic rocks. The paragneiss underwent major high-grade dynamothermal metamorphism in the late lower Proterozoic (Figure 3). Kyanite-

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[1] Adapted from Nunn, G.A.G. and Thomas, A., "The Labradorian Orogeny". Poster Session displayed at Canadian Tectonic Studies Group AGM, Maniwaki, Quebec (Oct. 27, 1984) and Newfoundland Department of Mines and Energy, Open House, St. John's, Newfoundland (Nov. 1-3, 1984).

[2] Department of Geology and Mineralogy, Royal Ontario Museum, Queen's Park, Toronto, Ontario M5S 2C6.

[3] More complete discussions of the structure, metamorphism and petrology associated with the Labradorian Orogeny will be found in Thomas, Nunn and Wardle (in press) and Thomas, Nunn and Krogh (in prep.).

LEGEND

Younger Cover

22 *Seal Lake Group; fluviatile and shallow marine sediments with basic volcanic rocks.*

21 *Letitia Lake Group; peralkaline volcanic rocks.*

20 *Blueberry Lake Group; felsic volcanic rocks.*

19 *Sims Formation; fluviatile sediments.*

Younger Plutons

18 *Other late granitoid rocks of unknown age.*

17 *Peralkaline intrusions.*

16 *Shabogamo Intrusive Suite; gabbroid rocks.*

15 *Elsonian granitoid rocks.*

14 *Elsonian anorthositic to noritic intrusions.*

Plutonic Interval

13 *Mackenzie Lake group; fluviatile sediments and acid-intermediate volcanic rock, coeval cover to TLB.*

12 *Trans-Labrador batholith (TLB); calc-alkaline quartz diorite to granite, predominantly granodiorite and quartz monzonite.*

11 *Gabbro, gabbronorite, layered gabbro-peridotite, hydrous gabbro and diorite (may include parts of Unit 16); associated with Unit 12.*

10 *Charnockitic granitoid rocks.*

9 *Norite-gabbronorite (may include parts of Units 14 and 16); associated with Unit 10.*

8 *Lac Fournier anorthosite.*

Ungava Batholith

7 *Massive to foliated granitoid rocks.*

Hudsonian Orthogneisses

6 *Amphibolite facies gneisses and foliated granitoid rocks.*

Aphebian Sedimentary Rocks

Labrador Orogen; semipelitic to pelitic paragneiss, probably derived from graywackes.

5 *Granulite facies gneisses.*

4 *Amphibolite and/or granulite facies gneisses.*

Hudson Orogen (north of Grenville Front) and/or Grenville Orogen (south of Grenville Front); shelf and slope sediments with basic volcanic rocks.

3 *Amphibolite facies metasediments and gneisses.*

2 *Greenschist facies metasediments.*

Archean Gneisses

1 *Granitoid gneisses with massive posttectonic granitic and alkaline plutons.*

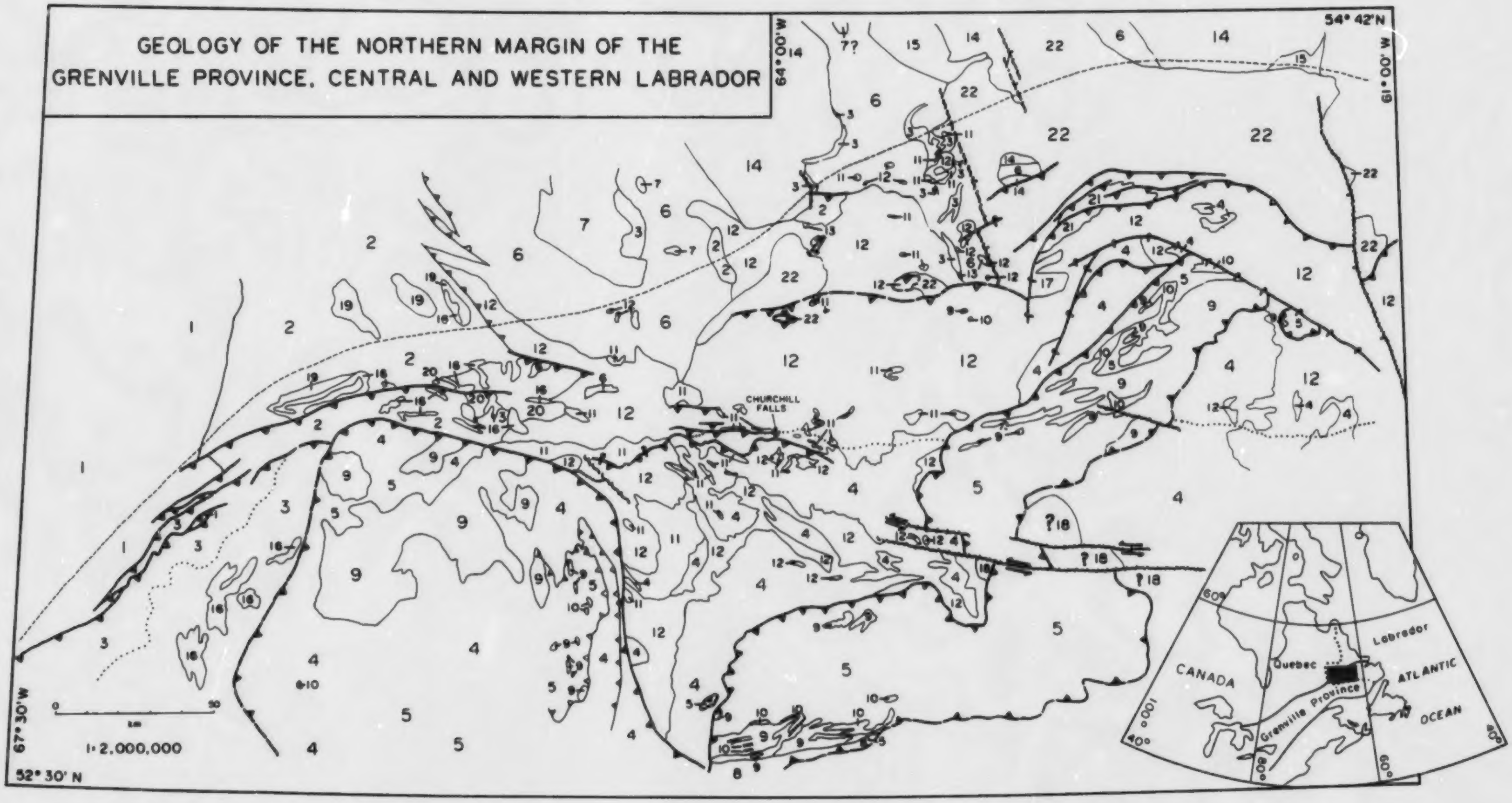

Figure 1: *Geology of the northern margin of the Grenville Province, central and western Labrador: preliminary compilation. Map compiled by Wardle, Nunn and Thomas. Adapted from earlier compilations at 1:1,000,000 scale by Wardle (1983) based on 1:100,000 scale mapping by (approximately W to E) Rivers, Ware, Wardle, Noel, Nunn, Culshaw, Thomas, Emslie and Ryan; and Greene (1972) based on Geological Survey of Canada, 1:250,000 scale mapping by Wynn-Edwards, Emslie, Stevenson, Eade, Roscoe and Fahrig. Most geological and structural boundaries inferred at 1:100,000 scale of mapping.*

SYMBOLS, FIGURES 1–7

∿∿∿∿∿∿	Post-Grenville faults - normal.
∿∿⇄∿∿	- strike-slip.
—┴—┴—┴—	Late Grenville reverse faults.
—▲—▲— —▲—	Post-metamorphic Grenville thrusts.
—△—△— —△—	Syn-metamorphic Grenville thrusts.
··················	Grenville migmatite isograd.
- - - - - - - - -	Grenville Front, approximate northern limit of ductile and major brittle to semi-brittle deformation of Grenvillian age.
—△—△—△—	Labradorian thrusts, in Lac Joseph allochthon.
—△—△—△—	Hudsonian thrusts, north of the Grenville Front.

LEGEND TO GEOCHRONOLOGY, FIGURES 3–7

U	Uranium-Lead
R	Rubidium-Strontium
S	Samarium-Neodymium
K	Potassium-Argon
A	Argon-Argon
i	Isochron
e	Errorchron
c	Combined isochron/discordia
p	Plateau age

z	Zircon
s	sphene
m	Monazite
a	Apatite
h	Hornblende
b	Biotite
mu	Muscovite
x	Eudialyte, Arfvedsonite, Micas, Nepheline, Pyroxene
wr	Whole rock

3500 upper intercept
1676 lower intercept

Numbers in parentheses following each date on the diagrams and in the paragraph below refer to the list of geochronological sources.

U-Pb data give concordia and discordia dates ranging from 3500 Ma to 638 Ma. The data from age determinations on all sphene samples were combined to produce a single discordia plot which yielded an upper intercept of 1654 Ma and a lower intercept of 993 Ma (Figures 4 and 6). The precision of 206Pb/238U versus 207Pb/235U ratios is 2σ for all U-Pb dates except the 1738/638 Ma discordia. This last date was compiled and its precision is not known. Rb-Sr determinations give dates ranging from 1715 Ma to 900 Ma. The 1666 ± 14 Ma dates in these blocks represent a composite isochron, and include both amphibolite-grade paragneiss of the parautochthon and granulite-grade paragneiss of the Wilson Lake allochthon. In addition, the 1666 ± 18 Ma date, from an amphibolite facies paragneiss raft within the parautochthon granitoid rocks was also combined into this isochron (11). Precision of 87Sr/86Sr versus 87Rb/86Sr ratios is 1σ (11), (2) or 2σ(1). 40Ar-39Ar dates range from 1806 Ma to 905 Ma with a reported precision of 2 .

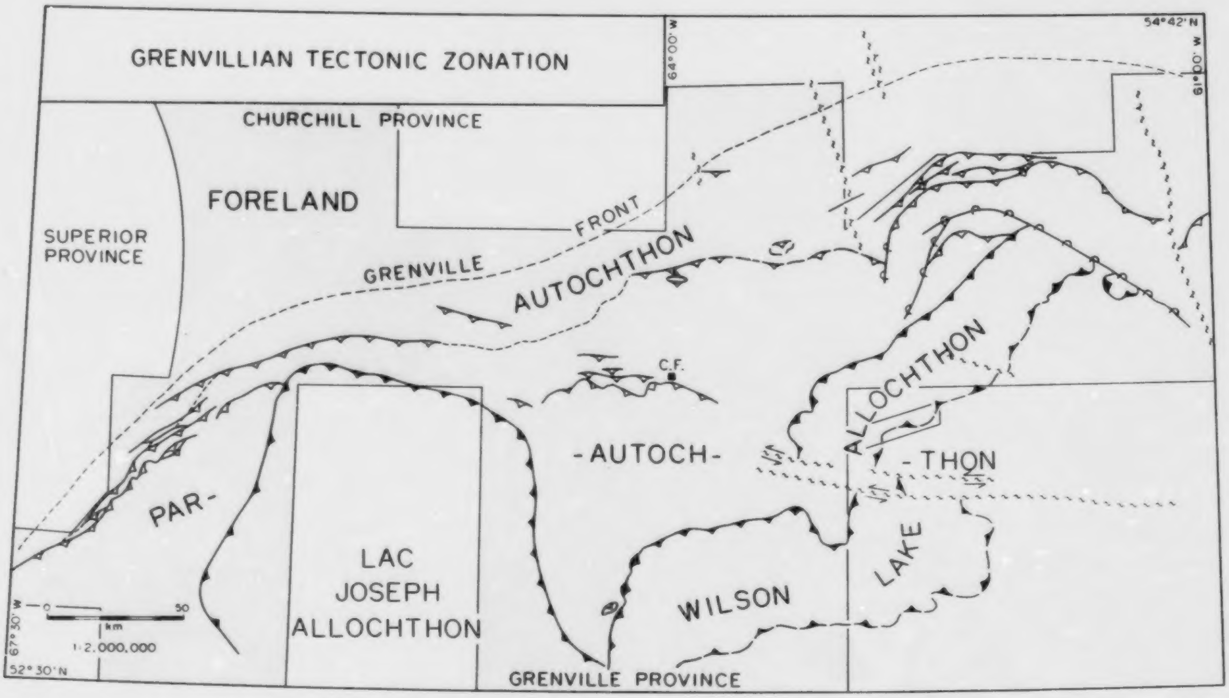

Figure 2: *Tectonic zonation of the northern part of the Grenville Province in central and western Labrador, and the distribution of areas mapped at 1:100,000 scale since 1977. Structural symbols for this and the following diagrams as for Figure 1, western part after Rivers and Nunn (in press). Allochthons = major aeromagnetic, gravimetric and topographic features with structural, metamorphic and geochronological discordance to the parautochthon.*

and/or sillimanite-bearing mineralogies occur throughout and assemblages including hypersthene + sillimanite ± quartz ± sapphirine ± cordierite are common in the Wilson Lake allochthon (Figure 2). The latter indicates PT conditions possibly in excess of 800°C and 10 Kb.

The paragneiss was intruded by voluminous granitoid and gabbroid plutonic suites. In the north these rocks form a linear, predominantly granitoid batholith of calc-alkaline affinity (Thomas, 1981, in preparation) that was emplaced about 1654 Ma and is known as the Trans-Labrador batholith (Wardle and staff, 1982; Figures 1 and 4). In the allochthons gabbronorite and minor charnockitic granitoid rocks may be temporal or earlier (diachronous?) equivalents of the batholith.

Deformation followed the intrusion of the plutonic rocks, at high-grade in the allochthons and at greenschist facies in the batholith (Figure 5).

GEOCHRONOLOGY

The Labradorian deformation and temporally and spatially related plutonism have been divided into a three-stage cycle (Thomas, Nunn and Wardle, in press). These consist of (1) preplutonic deformation and metamorphism (early Labradorian, Figure 3), (2) emplacement of a predominantly calc-alkaline granitoid suite in the north and norite-gabbronorite-charnockite suites in the allochthons during a plutonic interval (the Trans-Labrador batholith, Figure 4), and (3) postplutonic deformation and metamorphism (late Labradorian, Figure 5). We also consider that there may be a causal link between the three stages. However, there is still considerable uncertainty as to how many of the prebatholith structures are Labradorian or older (Hudsonian) and similarly how many of the postbatholith structures are Labradorian or younger (Grenvillian or other).

Stage 1: early Labradorian.

Except in the Churchill and Superior Provinces, where the gneisses are presumed to be, respectively, Hudsonian (circa 1800 Ma) and Kenoran (circa 2600 Ma), the age of the earliest gneissosity in the paragneiss is unknown. It could be coeval with some of the high-grade, metamorphic fabrics in the area (early Labradorian) or be older, perhaps Hudsonian (Figure 3).

In the parautochthon, adjacent to the Wilson Lake allochthon, paragneiss occurs as rafts (up to 8 km across) in the Trans-Labrador batholith which is only locally

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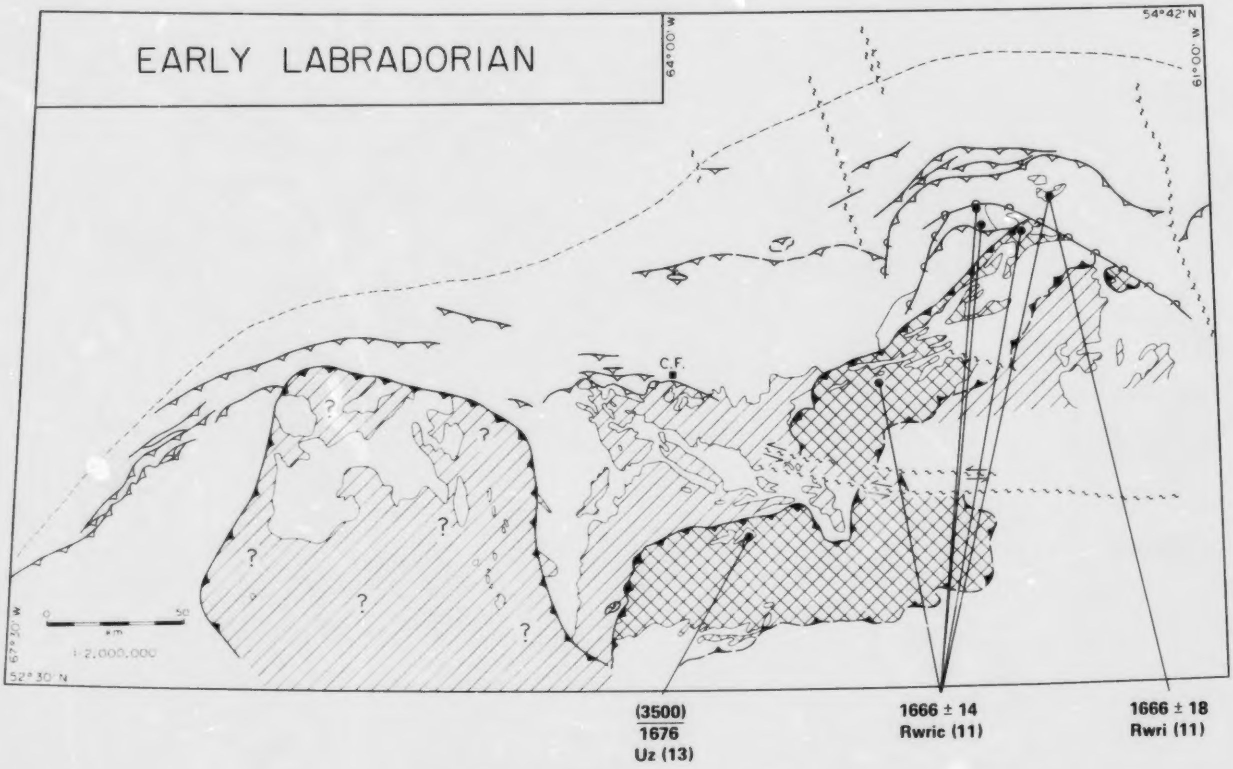

Figure 3: *Stage 1: early Labradorian dates, 1700-1650 Ma.*
Early Labradorian folding of preplutonic gneissosity and axial fabric development:—
Granulite facies ▩
Amphibolite and/or granulite facies ▨
Uncertain ?
Preplutonic gneissosity in all these areas may be Hudsonian and/or early Labradorian.

deformed at greenschist grade. The greenschist facies event is known to be Grenvillian since it affects both the batholith and its late Middle Proterozoic cover (the Seal Lake Group, Figure 1). The 1666 Ma combined isochron, therefore, relates to the high-grade events in the paragneiss and gives an age for the early Labradorian in the parautochthon (Figure 3). The authors feel that the 1676 to 1666 Ma dates from the Wilson Lake allochthon itself probably date the same high-grade, early Labradorian event. The overlap in dates between the metamorphic event in the paragneiss and the presumed emplacement age of the charnockitic suite (1675-1650 Ma, personal communication R.F. Emslie, 1980), however, could allow for these dates to record a post plutonic, stage-three, thermal or deformation event in the Wilson Lake allochthon.

Stage 2: the plutonic interval.

A minimum age for the early Labradorian events is given by the plutonic suites which crosscut the high-grade, metamorphic fabrics in the paragneiss. These consist of the emplacement of the Trans-Labradorian batholith in the parautochthon (1655-1650 Ma), the emplacement of the charnockitic suite in the Wilson Lake allochthon (1675-1650 Ma) and by a granitoid pluton (? circa 1672 Ma) that crosscuts the paragneiss gneissosity in the Lac Joseph allochthon. The timing of emplacement of the plutonic suites comprises the plutonic interval (Figure 4). Evidence for the age of much of the main component of the plutonic interval, the Trans-Labrador batholith, at 1655-1650 Ma now seems overwhelming. A date of 1619 Ma, from the Lac Joseph allochthon, and two dates of circa 1576 Ma, from northeast of Chruchill Falls, (Figure 4) indicate that there are younger plutons or phases present. Though included on Figure 4 the pluton dated at 1619 Ma appears to be posttectonic to the late Labradorian (personal communication T. Rivers, 1984) and is not strictly a part of stage 2.

Just northeast of the area individual plutons included within the batholith may range down to circa 1500 Ma in age (Ryan, in press). Plutonic rocks within the allochthons, though similar in age to those in the autochthonous zones, have not been

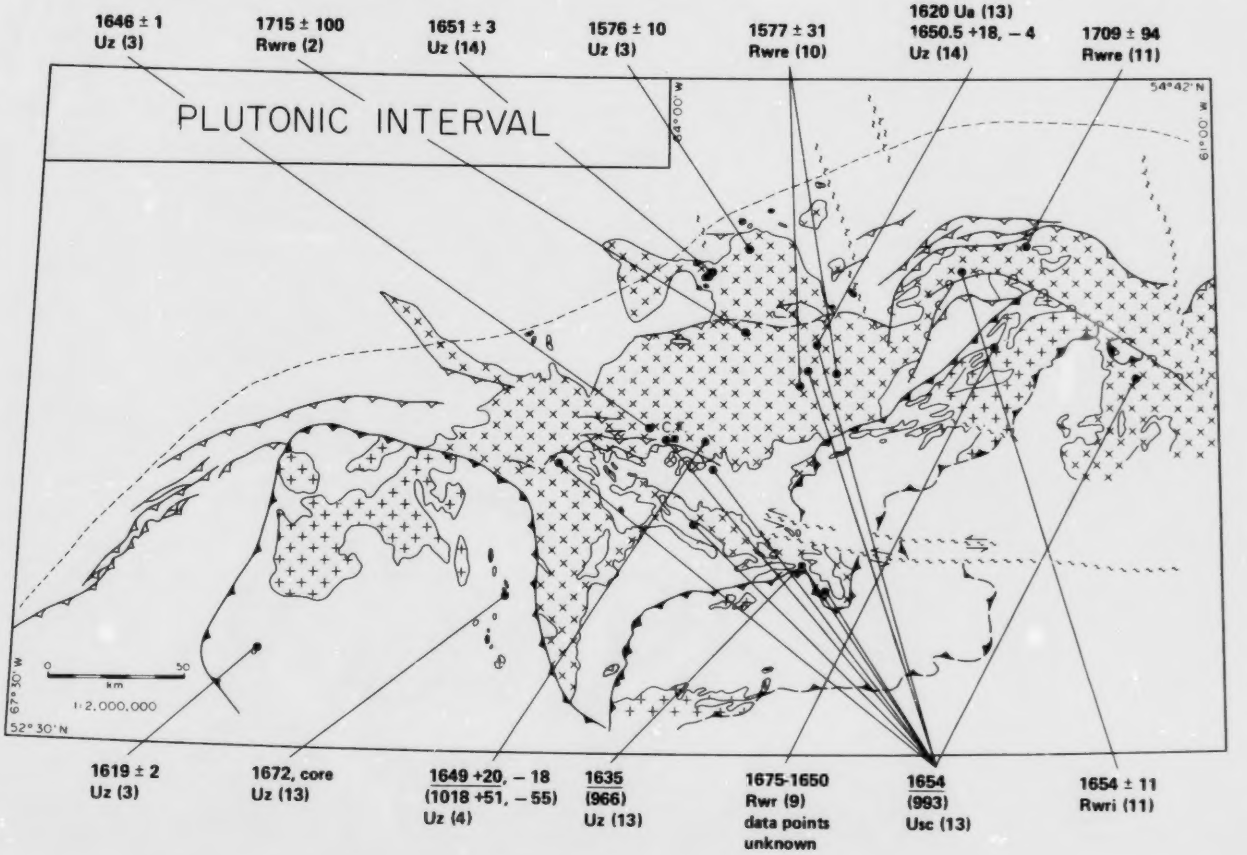

Figure 4: *Stage 2: the plutonic interval, 1675-1650 Ma.*
Trans-Labrador batholith (TLB) and spatially associated gabbroid suites × × ×
Norite-gabbronorite-charnockite: coeval or earlier than TLB but including some spatially associated younger gabbros + + +
Mackenzie Lake group: coeval cover to TLB ■

included in the Trans-Labrador batholith because they have been transported to the north-northwest during the Grenvillian Orogeny and initially may have been separated from the batholith by many tens of kilometers.

Stage 3: late Labradorian.

In the Lac Joseph allochthon fresh, clear zircons, from a granite pluton containing paragneiss xenoliths, have yielded concordia dates of 1645 and 1647 Ma (Krogh, 1983). A zircon core from the same pluton yielded a date of 1672 Ma. The pluton contains a weak linear fabric that in other, similar plutons ranges from a weakly to a strongly developed fabric with a granulite facies mineralogy and which coincides in orientation with a penetrative mineral recyrstallization at sillimanite grade in the paragneisses. This deformation was regionally pervasive and ranged from amphibolite to granulite facies. We interpret these data to indicate that the Lac Joseph allochthon underwent gneiss-forming deformation in the paragneisses at Hudsonian or early Labradorian time, granitoid emplacement circa 1672 Ma, and pervasive high-grade metamorphism and deformation during the late Labradorian (circa 1646 Ma).

Although the analyzed zircons appear to represent new metamorphic grains and overgrowths, and to date the pervasive upper amphibolite to granulite facies metamorphic fabrics in the allochthon, it is possible that they are relict igneous grains in which the U-Pb systematics survived a pervasive Grenvillian recrystallization. The recrystallization may have occurred at PT conditions rather less than those normally associated with the granulite facies, due to the anhydrous nature of the rocks.

Whereas the Lac Joseph allochthon was pervasively deformed during the late Labradorian the Wilson Lake allochthon was only selectively reworked following the emplacement of the norite-gabbronorite-charnockite plutonic suites. In the Wilson Lake alloch-

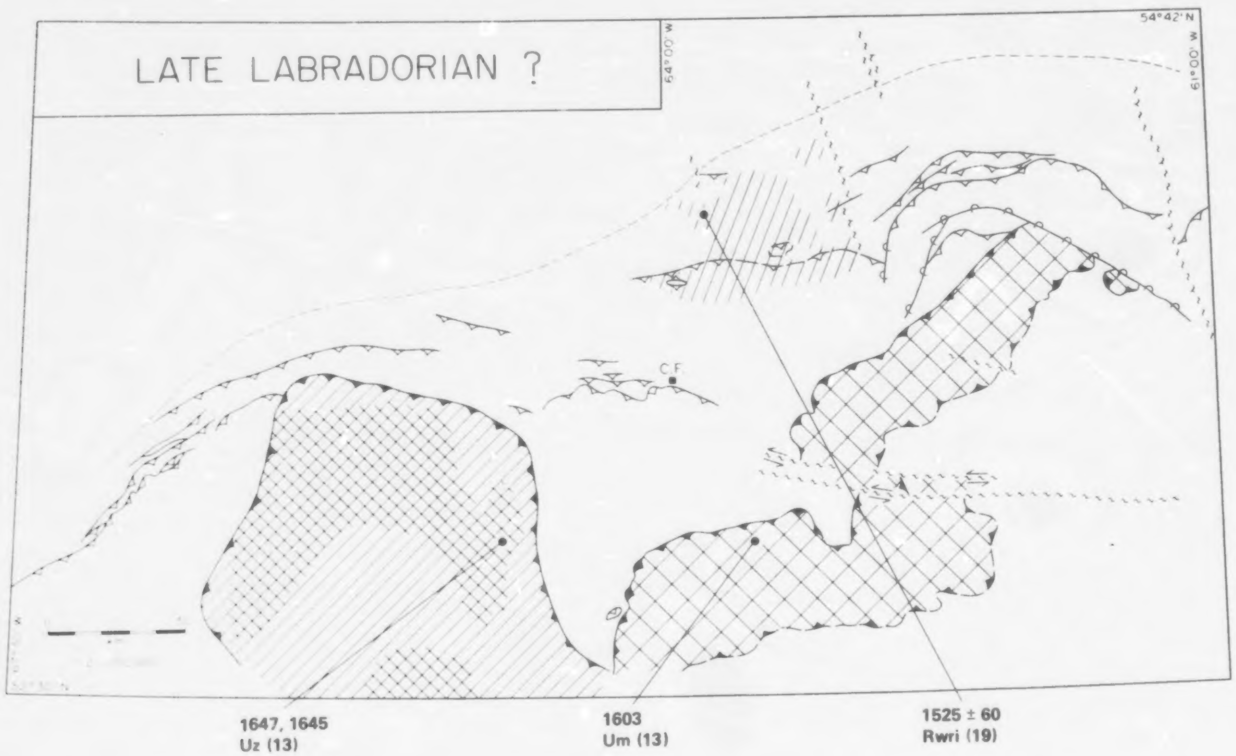

Figure 5: *Stage 3: late Labradorian?, 1670-1600 Ma.*
Late Labradorian or younger deformation:—
Selective, commonly in shear zones - *Granulite facies* ▨
- *Greenschist facies* ▨
Penetrative - *Granulite facies* ▨
- *Amphibolite and/or granulite facies* ▨

thon the deformation occurs in wide shear zones which contain granulite facies mineralogies and commonly have very strong south-southwest plunging lineations. This lineation is coincident in orientation and intensity with that associated with the Grenvillian Orogeny and widely recognized throughout the Grenville Province, particularly along its northern margin (Wynne-Edwards, 1972). The shear zones themselves are undated. Postplutonic deformation in the Wilson Lake allochthon could, therefore, range from late Labradorian to Grenvillian in age. If the 1676 and 1666 Ma dates on the paragneiss in the Wilson Lake allochthon do indeed represent a post plutonic event (instead of stage 1) the three-stage, deformation - plutonism - deformation cycle in this allochthon is an earlier (but perhaps diachronously related) cycle than that seen to the north involving the Trans-Labrador batholith.

Low-grade deformation followed the emplacement of the Trans-Labrador batholith throughout its northern parts sometime within the interval 1650 Ma to 1330 Ma (deposition of late Middle Proterozoic cover) and most probably prior to circa 1480 Ma (age of Michikamau anorthositic Intrusion). The steeply-dipping, north-northeast-striking fabric is only locally developed and is only known from the granitoid rocks of the batholith and the coeval cover sequence. It is most commonly represented by a weak phenocryst and xenolith alignment in an apparently undeformed igneous groundmass but ranges in intensity to narrow zones of mylonite. These relationships suggest a syn- to post plutonic, protoclastic style of deformation related to regional tectonism during emplacement of the batholith (1655-1600 Ma). The 1525 Ma date (Figure 5) is a Rb-Sr isochron from coeval, acid volcanic cover rocks which contain greenschist facies assemblages (Emslie in Wanless and Loveridge, 1978) and provides an alternative guestimate for the age of this fabric. This deformation may have been more extensive but has only been preserved in the northern margin of the Grenville Province in strain augen that remained undeformed during the Grenvillian Orogeny (Nunn and Noel, 1982). The deformation, if present throughout the batholith, was unlikely to have exceeded low-grade since all the sphene samples from the batholith show only one generation of lead loss (normal blocking temperature for lead in sphene

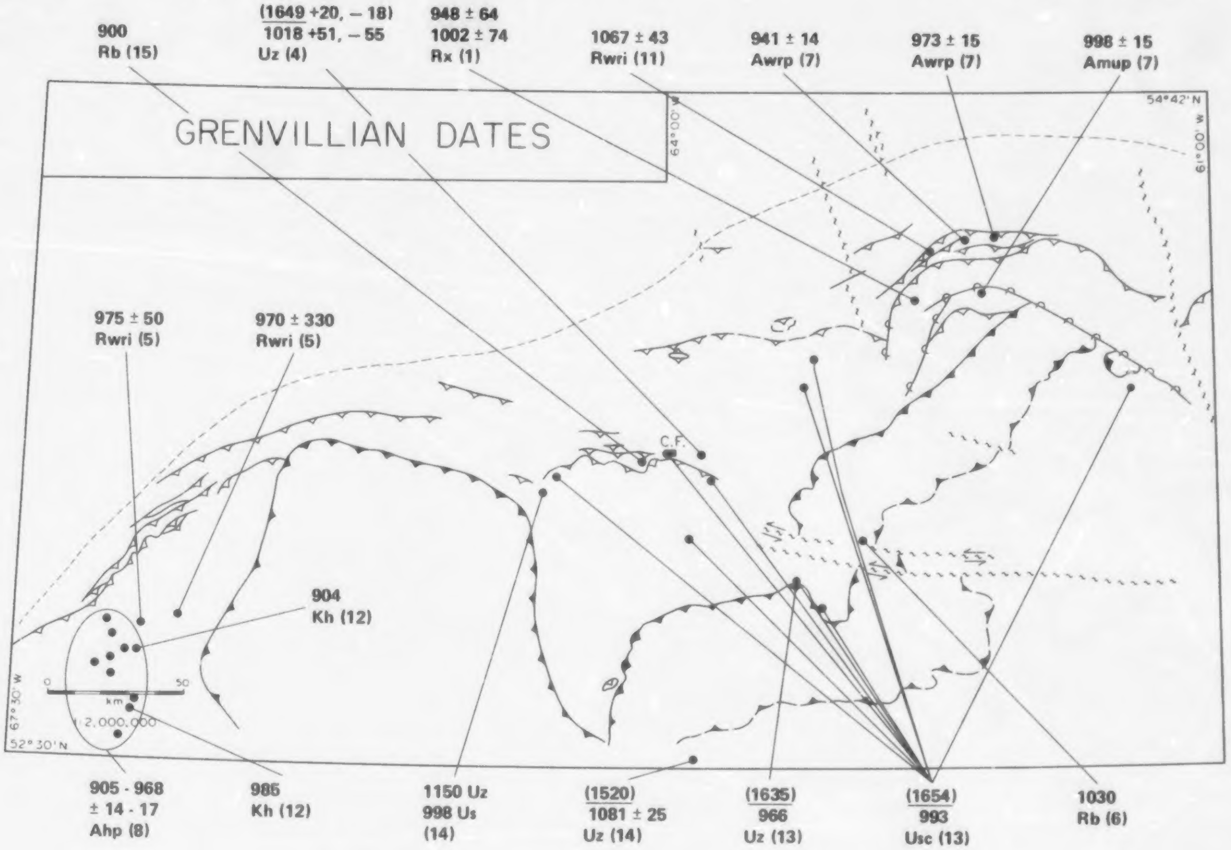

Figure 6: *Grenvillian dates, 1200-900 Ma.*
Grenvillian K-Ar cooling ages in the region range down to circa 800 Ma.

500-550°C) and this was the result of a Grenvillian event (Figure 6).

If the later phases or plutons in the Trans-Labrador batholith do indeed range down to 1570 Ma or younger the 1525 Ma guestimate for the age of the north-northeast striking fabric may be more reliable than the 1655-1600 Ma possibilitiy and the late Labradorian may be confined to the allochthons.

GRENVILLIAN OROGENY

Superimposed Grenvillian dynamothermal metamorphism (Figure 6) ranges from lower greenschist facies in the north of the area to granulite facies in the south of the area and varies in effect from partial or complete resetting of low temperature geochronological systems to new mineral growth of zircon.

A number of other, and commonly enigmatic, dates have been obtained from the area (Figure 7). Some possible explanations are given with the diagram.

Many K-Ar and Ar-Ar dates on biotite, muscovite and whole rock samples, which range from 850 to 2000 Ma, have been omitted from Figures 6 and 7 because of potential problems of excess argon in phyllosilicates in a zone along the northern margin of the Grenville Province. Many of these dates, however, do relate to cooling following the Grenville Orogeny. This phenomenon is discussed with reference to biotite by Dallmeyer and Rivers (1983). Only the most extreme examples of excess argon contamination (dates 2000 Ma) have been included in Figure 7.

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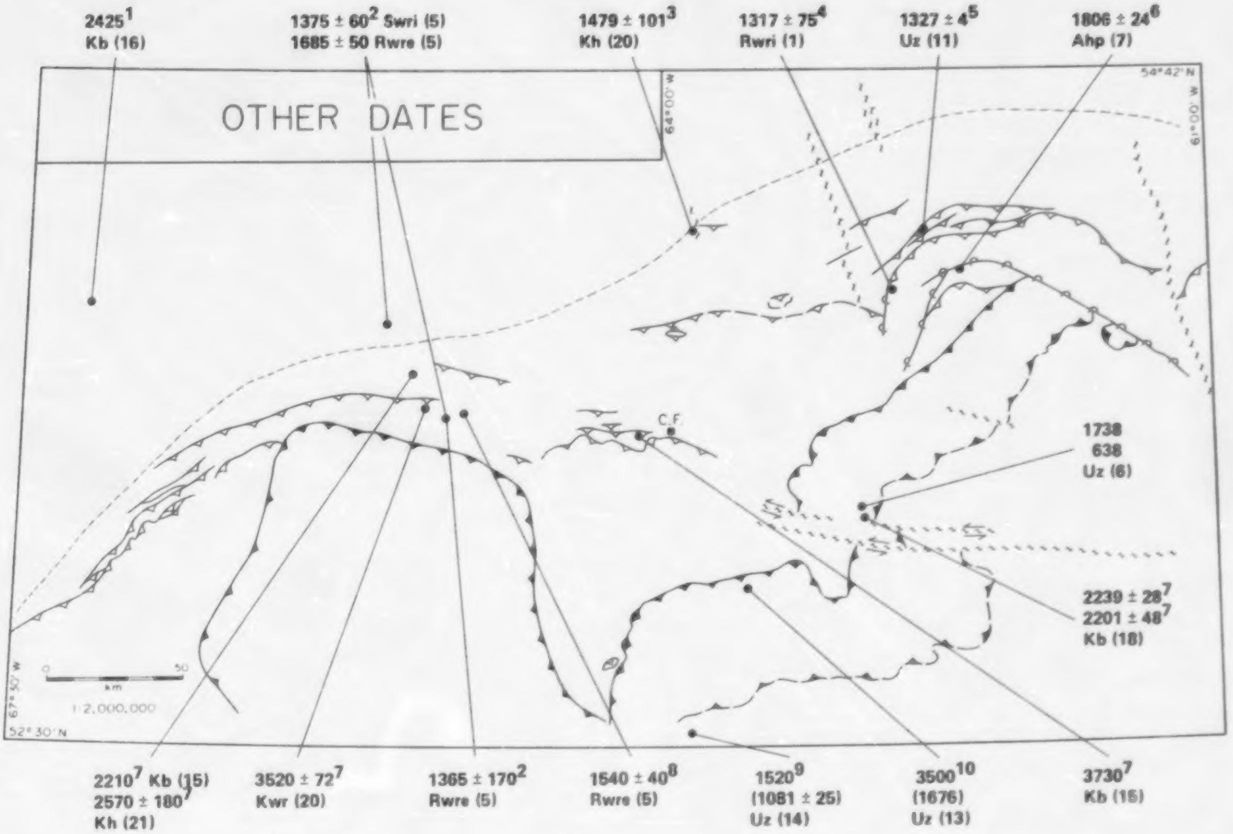

Figure 7: *Other dates.*

Subscripts:
1 *Kenoran cooling age (Unit 1, Figure 1).*
2 *Age of Shabogamo Intrusive Suite (Unit 16, Figure 1).*
3 *Age of Michikamau anorthositic Intrusion (Unit 14, Figure 1).*
4 *Age of peralkaline intrusive complex (Unit 17, Figure 1).*
5 *Age of Letitia Lake Group (Unit 21, Figure 1).*
6 *?tectonic inclusion from Churchill Province basement to thrust sheets.*
7 *Excess argon.*
8 *Age of Blueberry Lake group (Unit 20, Figure 1).*
9 *Poorly constrained upper intercept.*
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Quaternary Mapping
Moran Heights, Labrador
and Gander-Gambo area, Newfoundland

by

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Quaternary Geology Section

ABSTRACT

Quaternary mapping at Moran Heights has defined a regional ice flow to 050 followed by a later recessional ice flow to the north. A program of till sampling is recommended as follow-up to define a source area for uranium bearing boulders.

Regional Quaternary mapping in the Gander-Gambo area was continued and further results are expected to be released in 1985. In addition a need for consultation between the Quaternary Geologist and Soil Scientist is highlighted.

A. Moran Heights, Labrador, 13K/10

In 1984, Saarberg Interplan carried out a uranium exploration project on ground formerly held under joint venture by CANICO and BRINEX (Perry, 1980). The area (Figure 1) contains a concentration of uranium-bearing boulders situated between a ridge of basalt and a small lake. The former property holders had concluded that the boulders were in colluvium derived from the hillside above. Drilling in this area had failed to intersect any significant amounts of mineralization. The author visited the site at the request of Saarberg to help resolve the question of glacial transport.

Quaternary mapping using landform classification on 1:50,000 and 1:15,840 airphotos plus ground truthing during three days of field work established two ice flow events. The first was a regional glacial flow (1 on Figure 2) towards 050 which was followed by a later advance (2 on Figure 2) consisting of a small lobe of ice that occupied the valley area at Moran Heights. Flow during this later recessional event was to the north, as shown by striae, grooves, and streamlining and stossing (roche moutonnée) of outcrop areas at the north end of the pond.

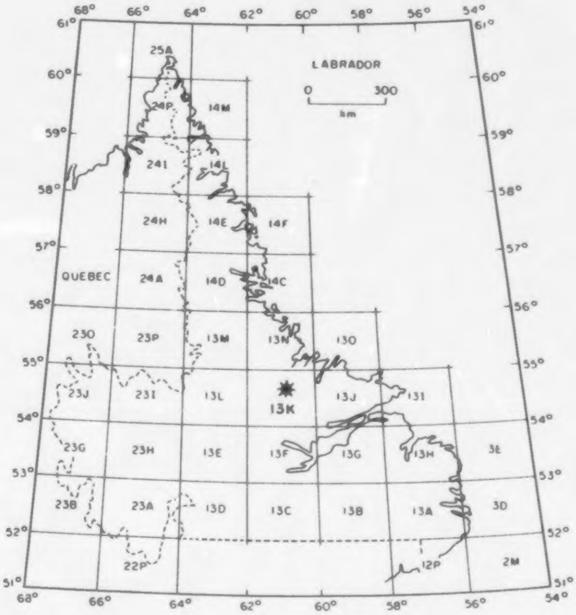

Figure 1: *Index Map, Moran Heights, 13K/10.*

The southward retreating ice lobe stalled and built a substantial recessional moraine (Figure 2) at the north end of the pond. In addition, remnants of lateral moraines can be discerned on each side of the valley. Preliminary till and pebble studies in the vicinity of the main boulder concentration indicate that the drift materials are till, containing a mixture of clasts derived from Archean granites and gneisses, Aphebian basalts, and Helikian sandstones and siltstones. The basalts are most probably from the Moran Group (forming the hillsides) and the sandstones and siltstones from the Haggart Formation that lies buried beneath the drift in the valley.

In conclusion based upon land form observations and pebble lithology data, the uranium-bearing boulders do not occur within colluvium as previously assumed but are within a till derived from the south or southwest of the main boulder concentration. The distance of transport from the

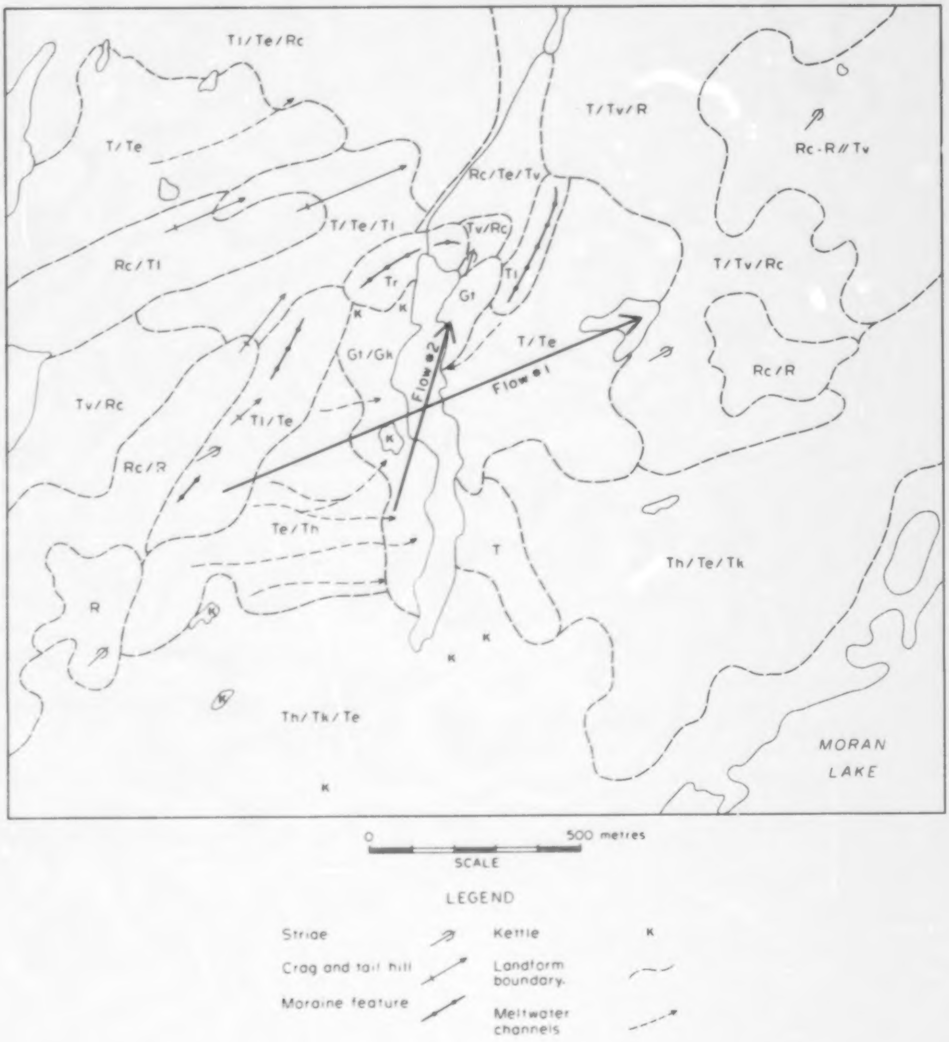

Figure 2: *Moran Heights Quaternary Mapping, 1984*
Landform Classification: T - till undiffereniated; Te - till thicker than 3 m, dissected by gullies; Tv - thin till less than 3 m deep; Th - thick till in hummocks or mounds, thickness greater than 3 m; Tl - lineated till, thickness greater than 3 m; Tk - till with kettle holes, due to deposition of till with ice blocks; Tr - till ridge deposited transverse to direction of glacial transport, greater than 3 m thick. R - barren rock or rock with minor scattered vegetation or organic cover; Rc - rock concealed by vegetation or thin organic or drift cover less than 0.5 m deep. G - glaciofluvial outwash; Gt - glaciofluvial terrace; Gk - glaciofluvial outwash deposited with ice blocks, water filled kettle holes present.

Examples: *Tr - 100% of landform is a till ridge.*
T/Te - 60 to 85% of landforms undifferentiated till, 15% to 40% of landforms consist of till dissected by gullies.
Th/Te/Tk - 55 to 80% of landforms in hummocks/15 to 40% till dissected by gullies/5 to 15% of landforms till with kettle holes.

source area could not be determined during this preliminary reconnaissance. Definition of a target area might best be established using a detailed till sampling program (50 m spacing along grid lines 100 m apart) over the boulder area plus a region extending up to 1 km southwest of the boulder field. In addition, pebble lithologic analyses on a 100x100 m grid pattern would be useful combined with till geochemistry in order to distinguish between uranium enrichment in tills derived from either the basalts of the Moran Group or the sandstones of the Haggart Formation. Follow-up after the till sampling program should include profile till sampling to the southwest of geochemically anomalous till areas to further define a drill target.

B. Gander - Gambo, Newfoundland, 2D/16, West Half

During 1983, Quaternary mapping and regional till sampling were conducted on the Weir's Pond map area (2E/1) and on parts of the Gambo map area (2D/16) north of the Trans-Canada Highway (Butler et al., 1984).

In 1984, this work was extended to cover the west half of 2D/16 (Figure 3), particularly the area south of the Trans-Canada Highway and around Soulis Pond. This work was aimed at ground truthing the airphoto interpretation (landform classification) and to obtain additional till samples for grain size, pebble lithologic and geochemical analyses.

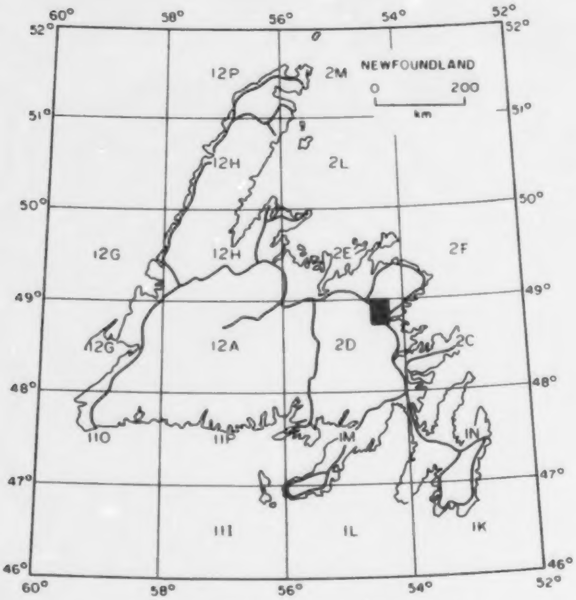

Figure 3: *Index Map, Quaternary Mapping, 1984, Gambo, 2D/16, west half.*

Preliminary observations from the 1984 work confirm that two ice flows affected the area. The earlier flow was easterly while the later flow was in part topographically controlled, with radial ice flow and drawdown towards Gander Bay and Freshwater Bay, respectively. Drift south of Gander Lake is considerably thicker than in other parts of the area. In addition, an extensive ice contact, outwash system between Gander Lake and Dark Cove indicates that proglacial drainage through Gander Lake area during retreat was through the east end of the lake rather than the current drainage via Gander River to Gander Bay. Geochemistry and other data are expected to be released in 1985.

C. Liaison: Soil Scientists - Quaternary Geologists

Quaternary geologists, geochemists and exploration geologists often use soils as a sample medium or attempt to penetrate through the upper area of pedogenic (soil) development.

The need for a close working relationship between the geochemist and the Quaternary geologist has been identified by others (Coker, 1983).

There is also a growing need for Quaternary geologists and soil scientists to come together to distinguish between what is primary or depositional in character and what is the result of soil-forming processes when interpreting data from this sample medium. Some examples requiring attention or clarification are as follows: (a) distinguishing fragipans, a hard platy soil formation 15 to 30 cm deep, from fissility associated with lodgement till; (b) decreases in water mobility caused by the formation of impervious placic horizons (thicker than 3 cm called ortftein); and (c) deducing the effects of these soil-forming processes on the geochemical response in soils over mineralized terrain. Answers to some of these problems are developing and will be reported as joint consultations continue between the geologists of the Quaternary Geology Section and soil scientists from Agriculture Canada and the Newfoundland Department of Rural, Agriculture and Northern Development.

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METALLOGENY OF PERALKALINE ROCKS IN LABRADOR: STRANGE LAKE PERALKALINE GRANITE AND LETITIA LAKE (MANN #1) SHOWING

by

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Mineral Deposits Section

This year was the first of a five year project designed to study the metallogeny of the Strange Lake Zr-Y-Nb-REE mineralization and the Letitia Lake Be-Nb mineralization. To date, the preliminary field work has been completed for the Mann #1 showing at Letitia Lake, while the Strange Lake Alkalic Complex has been mapped and sampled. The available drill core from both of these showings has also been relogged.

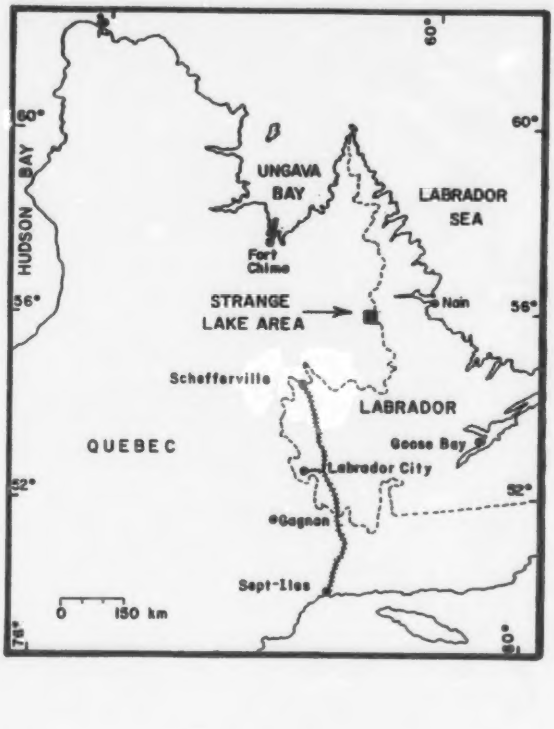
The Strange Lake Alkalic Complex, located west of Nain on the Quebec-Labrador border, was mapped and sampled during the summer. A 1:10,000 scale bedrock geology map incorporating drill core and outcrop data will be completed in the near future. Samples collected for thin section, geochemical and mineralogical studies are presently being prepared; thus, results should be available in 1985. Planned laboratory studies include:

a) microprobe mineral analysis,
b) mineral separation and analysis,
c) major, minor and rare earth element whole rock analysis,
d) fluid inclusion study,
e) petrographic characterization of samples,
f) radiometric age dating.

These studies will help to characterize the ore minerals, some of which are unnamed minerals, and will help to establish the conditions and processes involved in ore formation.

The Mann #1 showing, located on Letitia Lake, 160 km northwest of Goose Bay, was visited this summer to collect samples and to identify geological problems. The study of both the field and drill core samples from the mineralized zones and host rocks will help to establish the ore-forming processes for this unusual type of deposit. Preliminary observations suggest that the Be-Nb mineralization is associated with peralkaline veins and sills, and with the metasomatism associated with their intrusion. Laboratory work this winter will include geochemical and mineralogical studies. The mineralization and host rocks will be mapped next summer to produce a 1:2,400 scale bedrock map.

It is hoped that the studies outlined above will aid in the further development of these deposits, as well as continued exploration for similar occurrences in other parts of Labrador.



This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

CAMBRIAN-ORDOVICIAN BIOSTRATIGRAPHIC INVESTIGATIONS, GREAT NORTHERN PENINSULA, WESTERN NEWFOUNDLAND

by

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ABSTRACT

Well preserved, early Late Cambrian (Dresbachian) trilobites were collected for the first time from previously unmapped limestone beds of the Petit Jardin Formation in the Western Blue Pond area, east of Bellburns, Great Northern Peninsula, Newfoundland.

Reconnaissance lithostratigraphic sectioning and biostratigraphic sampling of James and Eastern Whale Islands revealed that the rocks exposed there belong to different units from those previously mapped on these islands.

Early Ordovician (early Arenig) Zone G_2 *trilobite faunas have been identified above newly discovered exposures of the Boat Harbour Formation "pebble bed" along Bateau Barrens Road and at Barbace Point (Port au Choix Peninsula).*

Detailed biostratigraphic sampling for trilobites and conodonts was continued in the Boat Harbour and Catoche Formations at Eddies Cove West and on Barbace and Catoche Points on the Port au Choix Peninsula. During the investigations on Catoche Point, three graptolite horizons were discovered, two of which were previously unknown. These horizons have resulted in the confirmation of previously proposed correlations between the standard Early Ordovician trilobite and graptolite zonations of North America.

A previously unknown trilobite fauna was discovered in undolomitized limestone remnants of the uppermost part of the Catoche Formation exposed about 1.4 km northeast of Table Point. An Early Ordovician (late Arenig) Zone I to J age is suggested for these rocks.

A previously known graptolite horizon at the base of the Aguathuna Formation yielded ***Didymograptus nitidus - patulus****. An Early Ordovician (late Arenig)* ***Didymograptus protobifidus*** *Zone to* ***Didymograptus bifidus*** *Zone age is tentatively proposed for this horizon.*

INTRODUCTION

The Cambrian-Ordovician carbonate deposits of the Great Northern Peninsula have been the object of regional taxonomic-biostratigraphic studies aimed at correlating western Newfoundland trilobite faunas with those of the standard Cambrian and Ordovician trilobite zonations of North America (Palmer, 1977; Ross, 1951; Hintze, 1953). This report discusses new trilobite (and graptolite) material obtained between July and October, 1984, from Western Blue Pond, James and Eastern Whale Islands (St. John Bay), Eddies Cove West, Port au Choix Peninsula and north of Table Point (see Figure 1). This augments the work of Fortey (1979a), Stouge (1982) Boyce (1983a,b), and Stouge and Boyce (1983).

LITHOSTRATIGRAPHY

Lithostratigraphic divisions of the Cambrian-Ordovician platformal sequence that were studied belong to the Petit Jardin, Boat Harbour, Catoche and Aguathuna Formations; these are described by Knight (this volume).

CAMBRIAN BIOSTRATIGRAPHIC INVESTIGATIONS

Well preserved trilobites were obtained for the first time from previously unmapped stromatolitic, oolitic, burrowed, flaser bedded and pebbly limestone beds of the Petit Jardin Formation on the western shore and 1.2 km west of Western Blue Pond (Figure 1). The trilobites collected include *Arapahoia* sp., *Coosella* sp. cf. *C. helena* Lochman, *Terranovella* sp. cf. *T. obscura* Lochman and *Welleraspis* sp.. They are indicative of an early Late Cambrian (Dresbachian) *Cedaria-Crepicephalus* Zone age, and are correlative with similar faunas obtained from the Port au Port Peninsula (Lochman, 1938; Kindle and Whittington, 1965), Bear Cove Point, just north of Deadman's Cove (St. Barbe Coast) (Boyce, 1978; Boyce *in* Stouge and Boyce, 1983) and the south shore of Hawkes Bay (Knight and Boyce, 1984).

ORDOVICIAN BIOSTRATIGRAPHIC INVESTIGATIONS

James and Eastern Whale Islands (St. John Bay) were visited for reconnaissance

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

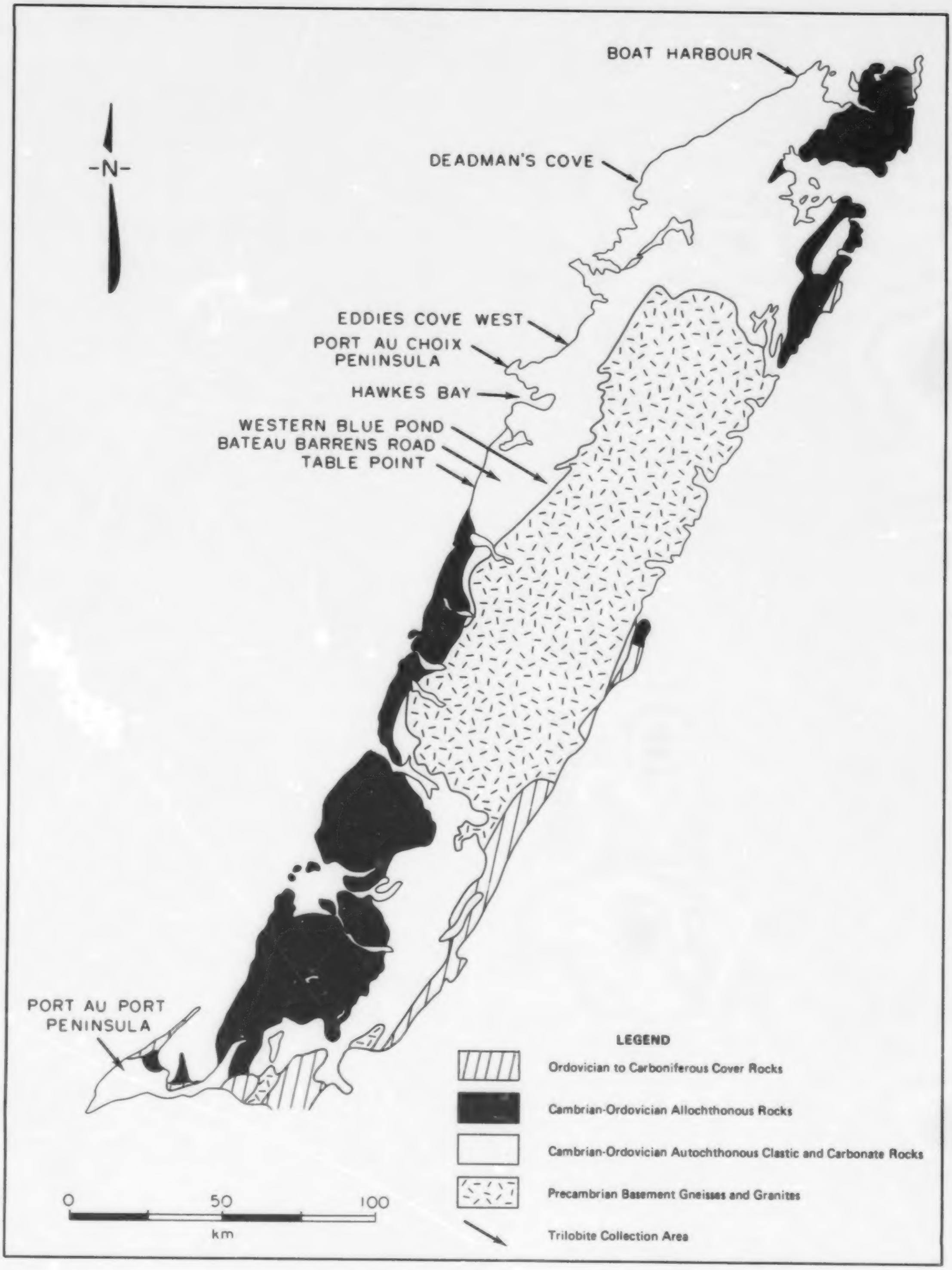
BOAT HARBOUR
-N-
DEADMAN'S COVE
EDDIES COVE WEST
PORT AU CHOIX PENINSULA
HAWKES BAY
WESTERN BLUE POND
BATEAU BARRENS ROAD
TABLE POINT
PORT AU PORT PENINSULA
LEGEND
Ordovician to Carboniferous Cover Rocks
Cambrian-Ordovician Allochthonous Rocks
Cambrian-Ordovician Autochthonous Clastic and Carbonate Rocks
Precambrian Basement Gneisses and Granites
Trilobite Collection Area
0
50
100
km

Figure 1: *Geological elements and trilobite collection areas of western Newfoundland.*

lithostratigraphic sectioning and biostratigraphic sampling. Limestones exposed on James Island were investigated to determine if they represented undolomitized remnants of the Watts Bight Formation as speculated by Knight and Boyce (1984, Figure 1). Lithologies and fossils found there, however, are typical of the Boat Harbour Formation below the "pebble bed" disconformity of Knight (1977, 1978, 1980, 1983), Boyce (1978, 1979, 1983a,b), Stouge (1982), Boyce et al. (1983) and Stouge and Boyce (1983). The following fossils were collected:

Trilobita
- *Hillyardina levis* Boyce, 1983b
- *Hystricurus pseudoculilunatus* Boyce, 1983b
- *Parahystricurus smithiae* Boyce, 1983b
- *Randaynia saundersi* Boyce, 1983b

Gastropoda
- *Lecanospira*
- *Ophileta*

Burrowed limestones, thrombolitic boundstones and parted limestones exposed on the northeastern tip of Eastern Whale Island proved to belong to the Catoche Formation rather than the uppermost Boat Harbour Formation as indicated by Knight and Boyce (1984, Figure 1). Fossils recovered are indicative of a higher stratigraphic interval well within the Catoche Formation. They include:

Trilobita
- *Bathyurellus abruptus* Billings, 1865
- *Benthamaspis conica* Fortey, 1979a
- *Bolbocephalus convexus* (Billings, 1865)
- *Isoteloides peri* Fortey, 1979a
- *Jeffersonia angustimarginata* Boyce, 1983b
- *Petigurus nero* (Billings, 1865)
- *Strigigenalis caudata* (Billings, 1865)

Cephalopoda
- *Cassinoceras/Piloceras* sp.

Gastropoda
- *Maclurites* spp.

Knight (this volume) discovered another exposure of the Boat Harbour Formation "pebble bed" along Bateau Barrens Road (Figure 1). Dolomitic limestones, a short distance above this horizon in two locations, yielded abundant articulate brachiopods and the following trilobites:

- *Isoteloides peri* Fortey, 1979a
- *Strigigenalis brevicaudata* Boyce, 1983b

These two species are characteristic of the early Arenig Ross-Hintze Zone G_2 fauna in the interval between the "pebble bed" and the base of the Catoche Formation in Boat Harbour (Boyce, 1983b).

Detailed biostratigraphic sampling for trilobites and conodonts was continued in the Boat Harbour and Catoche Formations exposed at Eddies Cove West and at Barbace and Catoche Points on Port au Choix Peninsula (Figure 1), augmenting the work of Fortey (1979a), Stouge (1982), Boyce (1983a,b) and Stouge and Boyce (1983).

Boyce (1983a,b) identified *Tesselacauda* sp. cf. *T. depressa sensu* Demeter (1973; Plate 1, Figures 5, 6) from a thrombolitic boundstone bed towards the base of the Boat Harbour Formation north of Eddies Cove West. This identification was based on an incomplete cranidium which did not show the genal angles. However, five cranidia recovered in 1984, which are more complete, all display well developed genal spines more characteristic of the genus *Rossaspis*. The cranidia, however, appear to be transitional between those of *Rossaspis pliomeris* Demeter, 1973 (Plate 2, Figures 1-4) and *Tesselacauda depressa* Ross, 1951 *sensu* Demeter (1973; Plate 1, Figures 5, 6) and final generic assignment of the species must await the recovery of pygidia.

Rossapis pliomeris Demeter is indicative of Ross-Hintze Zone D to earliest Zone E; *Tesselacauda depressa* Ross is indicative of Zone E (Demeter, 1973, page 43, Text - Figure 3).

At Barbace Point, four additional horizons were sampled in the Boat Harbour Formation above the newly discovered Barbace Point "pebble bed" (Knight, this volume) and below the base of the Catoche Formation. The following were obtained:

Trilobita
- *Bolbocephalus convexus* (Billings, 1865)
- *Grinnellaspis newfoundlandensis* Boyce, 1983b
- *Isoteloides peri* Fortey, 1979a
- *Jeffersonia angustimarginata* Boyce, 1983b
- *Peltabellia knighti* Boyce, 1983b
- *Petigurus nero* (Billings, 1865)
- *Strigigenalis brevicaudata* Boyce, 1983b

At Boat Harbour, the same fauna occurs above the "pebble bed" and below the Catoche Formation; it is indicative of an Early Ordovician (early Arenig) Zone G_2 age (Boyce, 1983b).

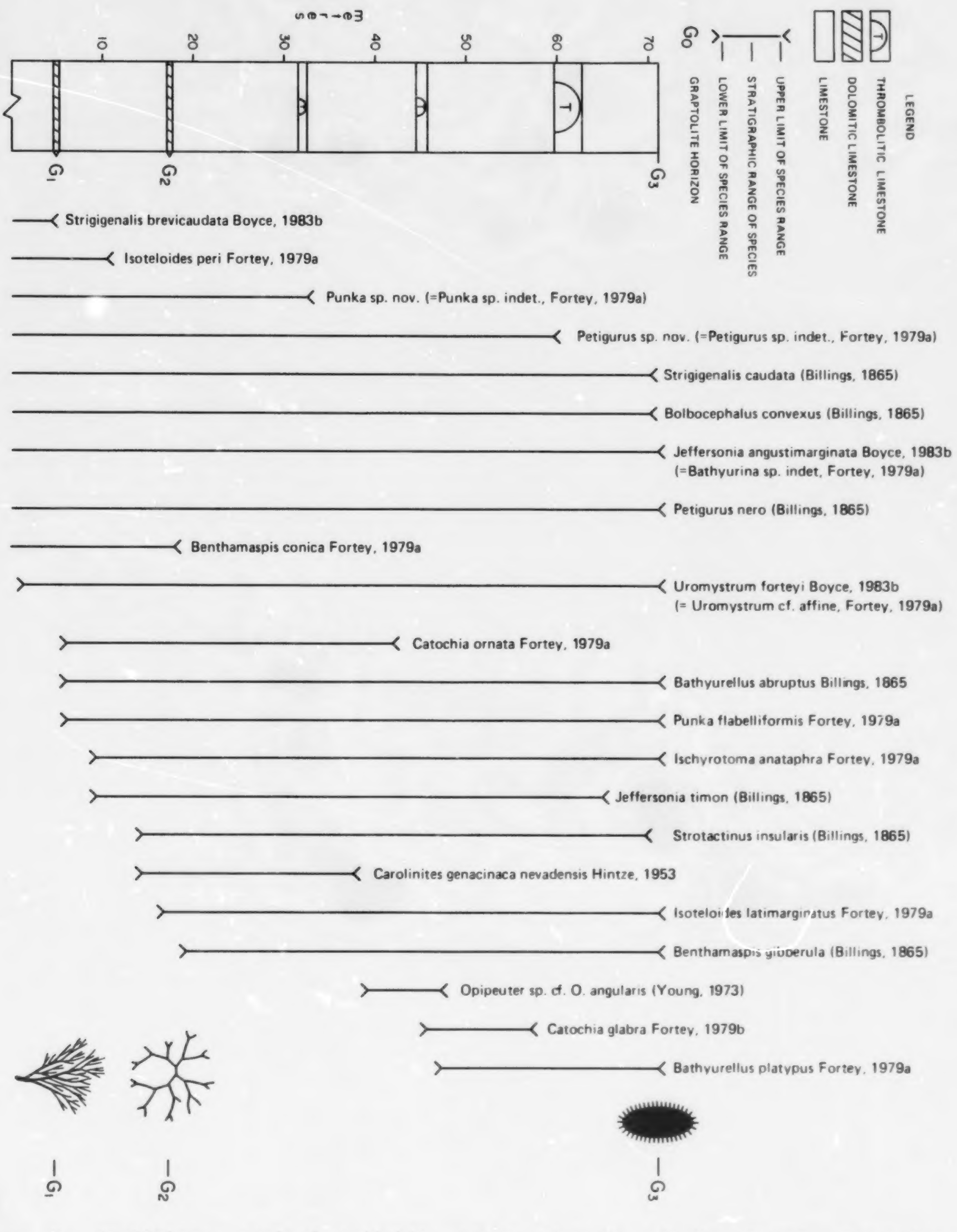

Figure 2: *Preliminary revised trilobite biostratigraphy of the Catoche Formation at Catoche Point, Port au Choix Peninsula. Range of* ***Carolinites genacinaca nevadensis*** *Hintze after Fortey (1979a, Figure 11). Graptolite horizons:* G_1 *- dendrograptid,* G_2 ***Clonograptus flexilis*** *(Hall),* G_3 *-* ***Pseudophyllograptus/Phyllograptus*** *sp.*

The type section of the Catoche Formation was the object of detailed biostratigraphic sampling for trilobites and conodonts for four weeks in September and October, 1984. The section, exposed at Catoche Point (south of Barbace Cove), was previously investigated by Dr. R.A. Fortey of the British Museum (Natural History). Fortey (1979a) described and illustrated twenty-one trilobite species (thirteen of which were new - including two new genera) obtained from thirteen fossiliferous horizons in the 70 m thick section. The author sampled forty-five fossiliferous horizons over the same interval. The tighter sample spacing resulted in a considerable revision of the biostratigraphic ranges of the trilobite species; most have substantially longer ranges than indicated by Fortey (1979a, Figure 11). The revised trilobite biostratigraphy is shown in Figure 2.

During the resampling of the Catoche Formation, three graptolite horizons were discovered, two of which are new. These horizons are shown in Figure 2 with the type of graptolite present in each. The lowest horizon (G_1) yielded a "nondiagnostic dendrograptid" (Dr. S.H. Williams, personal communication, 1984). The middle horizon (G_2) yielded *Clonograptus* (an identification confirmed by Drs. R.K. Stevens and S.H. Williams (personal communications, 1984); this horizon was originally discovered by Dr. L.M. Cumming of the Geological Survey of Canada, who obtained and illustrated well preserved *Clonograptus flexilis* (Hall) from it (Cumming, 1967, Figure 2). The highest horizon (G_3) yielded several specimens which resemble *Phyllograptus*. Because of their incomplete nature, however, it is impossible to discern whether they are *Phyllograptus* or *Pseudophyllograptus* (Dr. S.H. Williams, personal communications, 1984).

In terms of Berry's (1960) Marathon, Texas graptolite zonation, *Clonograptus flexilis* (Hall) ranges from the *Adelograptus - Clonograptus* Zone to the *Tetragraptus fruticosus* -4 branched Zone. Braithwaite (1976, page 52, Figure 10) also records *C. flexilis* from the top of Ross-Hintze Zone G_2 in Utah (see Figure 3). Fortey (1979, page 64, 102, 104) identified a cranidium of *Benthamaspis conica* Fortey which Berry (1960; Plate 7, Figures 1, 3) had illustrated (under a different name) from the *Tetragraptus fruticosus* -4 branched Zone. At Catoche Point, *C. flexilis* occurs within the range of *B. conica* (see Figure 2). This evidence implies at least a partial correlation between Ross-Hintze Zone G_2 and Berry's *Tetragraptus fruticosus* -4 branched Zone, the latter being equivalent to the lower half of the Arenig *Didymograptus deflexus* Zone of Great Britain (Jackson, 1964; Skevington, 1963, 1968, 1973) - see Figure 4. This is in accord with the conclusions of Flower (1978), Fortey (1979a) and Boyce (1983b).

In terms of Berry's (1960) graptolite zonation, *Pseudophyllograptus/Phyllograptus* ranges from the *Tetragraptus fruticosus* -4 branched Zone to the *Glyptograptus* cf. *G. teretiusculus* Zone. Braithwaite (1976, page 52, Figure 10) records *Phyllograptus* species (now assigned to *Pseudophyllograptus)* as ranging from the top of Ross-Hintze Zone G_2 to the top of Zone K - see Figure 3. Fortey (1976) showed that in Spitsbergen the range of the trilobite *Carolinites genacinaca nevadensis* Hintze extends into Berry's (1960) *Tetragraptus fruticosus* -3 and 4 branched Zone; *Carolinites genacinaca nevadensis* also occurs in Ross-Hintze Zone H (Hintze, 1953). Fortey (1979a, pages 100-102) also recognized *Benthamaspis gibberula* (Billings) as occurring in Zone H. At Catoche Point *Pseudophyllograptus/Phyllograptus* occurs stratigraphically above *C. genacinaca nevadensis* but associated with *B. gibberula*. The above data suggest that Ross-Hintze Zone H and Berry's *Tetragraptus fruticosus* -3 and 4 branched Zone are largely correlative and, therefore, both equivalent to the upper half of the Arenig *Didymograptus deflexus* Zone of Great Britain-Scandinavia (Jackson, 1964; Skevington, 1963, 1968, 1973) - see Figure 4. This agrees with the conclusions of Flower (1978), Fortey (1979a) and Boyce (1983b).

Undolomitized limestone remnants of the uppermost Catoche Formation exposed approximately 1.4 km northeast of Table Point yielded a previously unknown trilobite fauna. The following species were obtained:

- *Benthamaspis* sp. cf. *B. diminutiva* Hintze, 1953
- *Bolbocephalus* sp. undet.
- Gen. et spp. undet.
- *Goniotelina* sp. nov.
- *Ischyrotoma* sp. undet.
- *Isoteloides* sp. undet.
- *Jeffersonia* sp. cf. *J.jenii* Cullison, 1944
- ? *Strotactinus* sp. undet.

This new fauna ranges through approximately 8 m of strata; its top occurs about 10 m below a distinctive graptolite horizon which occurs at the base of the Aguathuna Formation (see below). The fact that the closest stratigraphically underlying trilobite fauna is of demonstrable Ross-Hintze Zone H age (Fortey, 1979a; Boyce, 1983a, this report) suggests that the new fauna is younger. The presence of *Benthamaspis* sp. cf. *B. diminutiva* Hintze

	GREAT BRITAIN		NORTH AMERICA - SPITSBERGEN				WESTERN NEWFOUNDAND
SYSTEM	SERIES	GRAPTOLITE ZONES	SERIES	STAGES	GRAPTOLITE ZONES	TRILOBITE ZONES	FORMATION
ORDOVICIAN	LLANVIRN	Didymograptus bifidus (European type)	CHAMPLAIN	WHITEROCK	Paraglossograptus tentaculatus	M	TABLE POINT
						L	AGUATHUNA
	ARENIG	Didymograptus hirundo	CANADIAN	VALHALLAN	Isograptus victoriae	" K "	(HIATUS)
		Isograptus gibberulus		CASSINIAN	Didymograptus bifidus	J	AGUATHUNA
		Didymograptus nitidus			Didymograptus protobifidus	I	?
		Didymograptus deflexus			Tetragraptus fruticosus (3 and 4 branched)	H	CATOCHE
					Tetragraptus fruticosus (4 branched)	G_2	
		(Tetragraptus approximatus)			Tetragraptus approximatus		
				JEFF.			BOAT HARBOUR
							(HIATUS)

Figure 4: *Summary of correlations proposed in this report. Correlation of North American - Spitsbergan trilobite and graptolite zones after Fortey (1976, 1979a,b, 1980) and Boyce (1983b). Correlation of British and North American graptolite zones after Skevington (1963, 1968, 1973) and Jackson (1964). Usage of Valhallan Stage after Fortey (1979b, 1980). Correlation of Aguathuna Formation partly after Stouge (1982). CHAMPLAIN. = Champlainian, JEFF. = Jeffersonian.*

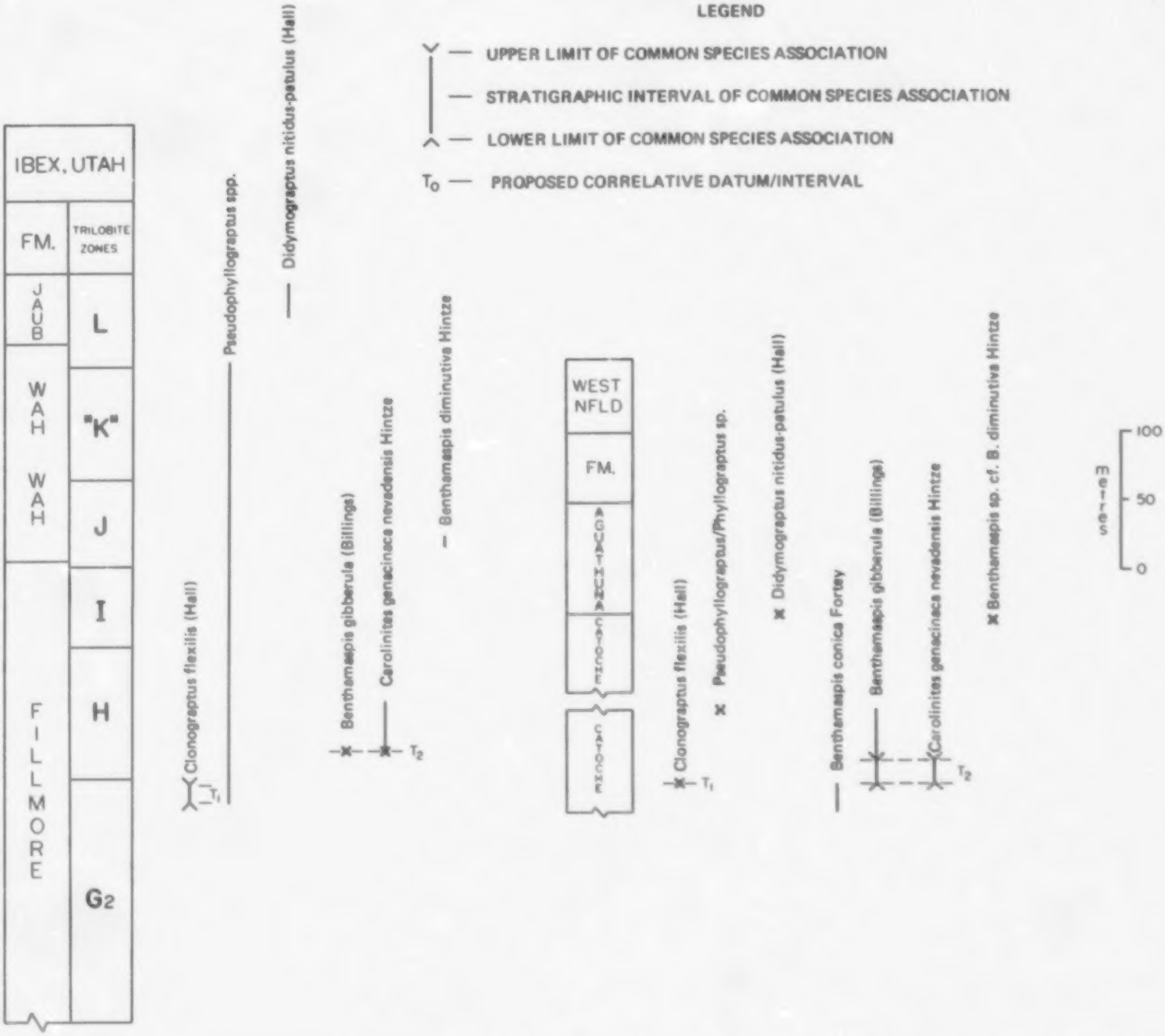
LEGEND
UPPER LIMIT OF COMMON SPECIES ASSOCIATION
STRATIGRAPHIC INTERVAL OF COMMON SPECIES ASSOCIATION
LOWER LIMIT OF COMMON SPECIES ASSOCIATION
T0 — PROPOSED CORRELATIVE DATUM/INTERVAL
IBEX, UTAH
FM.
TRILOBITE ZONES
JAUB
WAH WAH
FILLMORE
L
"K"
J
I
H
G2
Clonograptus flexilis (Hall)
T1
Pseudophyllograptus spp.
Didymograptus nitidus-patulus (Hall)
Benthamaspis gibberula (Billings)
Carolinites genacinaca nevadensis Hintze
T2
Benthamaspis diminutiva Hintze
WEST NFLD
FM.
AGUATHUNA
CATOCHE
Clonograptus flexilis (Hall)
T1
Pseudophyllograptus/Phyllograptus sp.
Didymograptus nitidus-patulus (Hall)
Benthamaspis conica Fortey
Benthamaspis gibberula (Billings)
Carolinites genacinaca nevadensis Hintze
T2
Benthamaspis sp. cf. B. diminutiva Hintze
metres
100
50
0

Figure 3: *Comparison and correlation of ranges of graptolite and trilobite species/ species associations common to Ibex, Utah and Port au Choix-Table Point, western Newfoundland. Ibex graptolite data after Braithwaite (1976); trilobite data after Hintze (1953) and Young (1973). Western Newfoundland graptolite data after Ruedemann (1947), Cumming (1967) and Boyce (this report); trilobite data after Fortey (1979a) and Boyce (this report). Note: Zone "K" and the appropriate interval of the Wah Wah Formation are not to scale.*

and the genus *Goniotelina* may indicate an age as young as Zone J because, in Utah, *B. diminutiva* is restricted to Zone J (Hintze, 1953, page 142, 143; Plate XIII, Figures 9-12) (see Figure 3). Stouge (1982, page 10, also Figure 4) and Stouge (*in* Stouge and Boyce, 1983, Figure 2.2) record the following conodont species from the uppermost part of the Catoche Formation north of Table Point:

Scolopodus? gracilis Ethington and Clark
Oistodus inaequalis Lindstrom
Oepikodus communis (Ethington and Clark)
Drepanodus arcuatus Pander
Semiacontiodus asymmetricus (Barnes and Poplawski)
Microzarkodina marathonensis (Bradshaw)
Juanognathus variabilis Serpagli

These species also occur in the Pogonip Group at Ibex, Utah. Unfortunately, they do not provide any more biostratigraphic precision than the trilobites. With reference to Ethington and Clark (1981, Figure 3), the minimum range of the above species assemblage is Ross-Hintze Zone H to J. This suggests that the uppermost Catoche conodont assemblage is of a similar age. Because it occurs stratigraphically well above a proven Zone H trilobite fauna, however, it is more probably of Zone I or J age. This is in accord with Stouge (1982, Figure 5). Final determination of the age must await more detailed examination of the trilobites and analysis of the conodont samples.

The graptolite horizon at the base of the Aguathuna Formation north of Table Point yielded many individuals of a species which the author identified as *Didymograptus patulus* (Hall). This horizon was originally studied by Ruedemann (1947, pages 341-342; Plate 55, Figure 22; Plate 56, Figure 17), who identified and described *D. patulus* from samples donated by Helgi Johnson. Subsequently, Lenz (personal communications, 1970 *in* Collins and Smith, 1975, page 403) reported "poorly preserved specimens of *Didymograptus* cf. *patulus* (Hall) and *Didymograptus* cf. *nitidus* (Hall)" from the same horizon and Erdtmann (1971, p. 1515, Table 1C) identified *Didymograptus patulus* from this locality (listed by him as Bateau Cove, Table Head). According to Ruedemann (1947, page 342) and Dr. S.H. Williams (personal communication, 1984), there is a marked intergradation in form between *D. patulus* and *Didymograptus nitidus* (Hall); it is the opinion of Dr. S.H. Williams (personal communication, 1984) that the two species can scarcely be distinguished and the best that one can do is to refer to them as *Didymograptus nitidus-patulus* group. Keeping this in mind, it is noteworthy that with respect to Berry's (1960) Marathon, Texas, graptolite zonation, *D. nitidus* ranges from the *Adelograptus* - *Clonograptus* Zone to the *Didymograptus protobifidus* Zone and *D. patulus* ranges from the *Tetragraptus fruticosus* -4 branched Zone to the *Didymograptus protobifidus* Zone. Fortey (1976) demonstrated a correlation of Ross-Hintze Zones I and J with Berry's (1960) *Didymograptus protobifidus* and *Didymograptus bifidus* Zones, respectively. However, Braithwaite (1976, page 52, Figure 10) also recorded both *D. nitidus* and *D. patulus* from the basal Whiterock Ross-Hintze Zone L in Utah (see Figure 3) which, according to Fortey (1979b, Text - Figure 3) correlates wih the basal Llanvirn European *Didymograptus bifidus* Zone, equivalent to Berry's *Paraglossograptus tentaculatus* (formerly *Hallograptus etheridgei*) Zone (Jackson, 1964; Skevington, 1963, 1968, 1973) - see Figure 4. Furthermore, Ruedemann (1947, page 341) reported that *D. patulus* "occurs in the Lower Llanvirn beds of the St. David's district in Wales associated with *D. bifidus*, *D. nicholsoni*, ...". This strongly suggests that *D. nitidus* - *patulus* has a greater range than was indicated by Berry (1960).

Because the basal Aguathuna Formation *D. nitidus-patulus* horizon occurs only about 10 m above possible Ross-Hintze Zone I to J trilobites and stratigraphically well above proven Ross-Hintze Zone H trilobites and probable *Tetragraptus fruticosus* -3 and 4 branched Zone graptolites, it is probably also of Ross-Hintze Zone I to J and *Didymograptus protobifidus* to *Didymograptus bifidus* Zone age (see Figure 4). This makes the fauna equivalent to the late Arenig *Didymograptus nitidus* to *Isograptus gibberulus* Zones of Great Britain (Jackson, 1964; Skevington, 1963, 1968, 1973). This is consistent with the fact that *D. nitidus-patulus* first appears in Bed 11 of the Cow Head Group (Kindle and Whittington, 1958) (Drs. R.K. Stevens and S.H. Williams, personal communications, 1984) which Whittington (1968, page 50, Table 4-1) correlated with Berry's Zones 4 to 7 (*Tetragraptus fruticosus* -4 branched to *Didymograptus bifidus* Zones). Lenz (personal communication, 1970 *in* Collins and Smith, 1975) assigned a latest *Tetragraptus fruticosus* -3 and 4 branched Zone age or a *Didymograptus protobifidus* Zone age to the basal Aguathuna Formation graptolite horizon; Erdtmann (1971, page 1515, Table 1C) tentatively assigned it a *Didymograptus protobifidus* Zone age.

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BIOSTRATIGAPHIC AND PALEOENVIRONMENTAL SIGNIFICANCE OF NEWLY DISCOVERED PALAEONISCID FISH AND VASCULAR PLANT REMAINS FROM THE SNAKES BIGHT FORMATION (ANGUILLE GROUP) NEAR CODROY, SOUTHWESTERN NEWFOUNDLAND

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Abstract

Articulated palaeoniscid fish and vascular plant remains have been recovered for the first time from the upper part of the Snakes Bight Formation (Anguille Group) near Codroy, southwestern Newfoundland. An Early Carboniferous, latest Tournaisian to earliest Viséan (= Early Mississippian) age is strongly indicated by the fossils, which favorably compare with those contained in the Albert Formation of southeastern New Brunswick and the Horton Bluff Formation of Nova Scotia. The Snakes Bight Formation was probably deposited in a freshwater, lacustrine environment rather than in marine conditions.

INTRODUCTION

The Snakes Bight Formation (Anguille Group) predominantly consists of thinly bedded black siltstones, mudstones and shales and thinly to thickly bedded gray sandstones; it also includes minor conglomerates, intraformational slump deposits and carbonate lithologies (Baird and Coté, 1964; Knight, 1983). Even though the formation had not yielded diagnostic nonmarine vertebrates that are common in the time-equivalent Albert Formation of New Brunswick and the Horton Bluff Formation of Nova Scotia (Bell, 1960; Carroll et al., 1972; Greiner, 1974), past workers generally interpreted it as a freshwater lacustrine deposit (Baird and Coté, 1964; Belt, 1969; Knight, 1983). Because no definitive nonmarine fossils were known, there remained some potential that the beds might be of marine origin (Knight, 1983, p. 31).

In June, 1984, P. Dean, J. Meyer, A. Best and D. Andrews discovered articulated fish remains near the top of the Snakes Bight Formation in the vicinity of Codroy, southwestern Newfoundland (Boyce et al., 1984) (see Dean and Meyer, this volume, Figure 2); unfortunately, at that time, most of the specimens proved impossible to collect. Because of the fishes' potential importance in determining the marine/nonmarine nature of the formation, the author visited the locality in July to retrieve the specimens and collect additional material, including plant remains.

All the fish collected display the thick, heavy, overlapping, diamond-shaped or rhombic black scales and deeply cleft shark-like heterocercal tail characteristic of the order Palaeoniscida (Colbert, 1980; Moy-Thomas and Miles, 1971; Romer, 1966). The following palaeoniscid genera have been identified: *Acrolepis*, ?Canobius, Elonichthys *and* Rhadinichthys. *The plants collected include* Aneimites acadica Dawson and *Asterocalamites scrobiculatus* (Schlotheim).

Note: The Codroy palaeoniscids are neither the first nor oldest fish fossils found in Newfoundland; their significance is that they are the first complete ones. Landell-Mills (1919, p. 7) and Hyde and Ware (1981, p. 25) report abundant fragmentary palaeoniscid debris from the Rocky Brook Formation (Deer Lake Group) of the Deer Lake Basin; Dr. R. Hyde also obtained an incomplete palaeoniscid from talus within the Anguille Group of the Deer Lake Basin (Dr. R. Hyde, personal communication, 1984). The oldest fossil fish so far obtained in Newfoundland are incomplete Silurian ostracoderms discovered by F. O'Brien at the base of the Clam Bank Formation on Port au Port Peninsula (F. O'Brien, personal communication, 1984).

BIOSTRATIGRAPHIC SIGNIFICANCE OF THE COLLECTED FLORA AND FAUNA

Aneimites acadica Dawson and *Asterocalamites scrobiculatus* (Schlotheim) both occur in the Horton Bluff and Cheverie Formations (Horton Group) of Nova Scotia (Bell, 1960). *Aneimites acadica* Dawson also occurs in the Albert Formation of southeastern New Brunswick (Lambe, 1910; Bell, 1960) and has been reported from Lower Carboniferous strata in Scotland (White, 1927).

With respect to the palaeoniscid genera in the Snakes Bight Formation, *Acrolepis* also occurs in the Horton Bluff Formation of Nova Scotia (Dawson, 1878; Carroll et al., 1972), and *Canobius*, *Elonichthys* and *Rhadinichthys* occur in the Albert Formation of New Brunswick (Lambe, 1910; Gussow, 1953; Greiner, 1974). The *Rhadinichthys* from the Snakes Bight Formation (see Figure 1) in fact may be con*specific with the Albert Formation species* R. alberti *(Jackson) illustrated by Lambe (1910).* Acrolepis, Canobius, Elonichthys

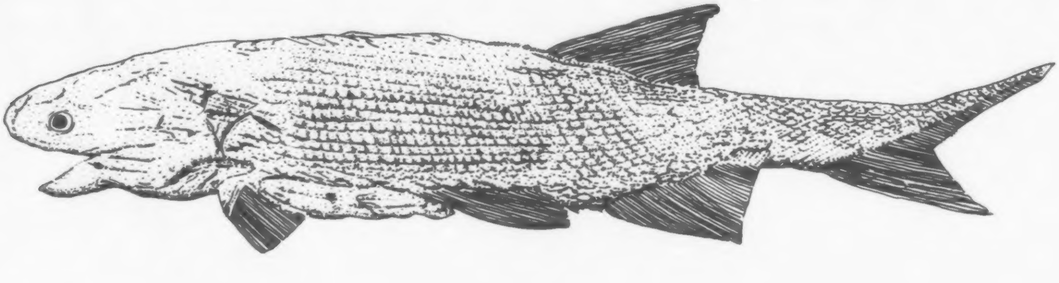

Figure 1: *Artist's reconstruction of **Rhadinichthys** sp. cf. **R. alberti** (Jackson) obtained from the top of the Snakes Bight Formation (Anguille Group) near Codroy, western Newfoundland. Approximately natural size. Reconstruction by Dave Leonard, based on nearly complete specimen.*

and *Rhadinichthys* are also common in Lower Carboniferous strata in Scotland (Traquir, 1903; Moy-Thomas and Bradley-Dyne, 1938; Schram, 1983).

Based on the above floral and faunal similarities, the top of the Snakes Bight Formation at least, is regarded as biostratigraphically correlative with the Horton Bluff and Cheverie Formations (Horton Group) of Nova Scotia and the Albert Formation of southeastern New Brunswick. Bell (1960) and Playford (1963) assigned these formations an Early Carboniferous, Tournaisian (Early Mississippian) age on the basis of their contained macroflora and microflora, respectively. Barss (*in* Hacquebard, 1972, p. 73, Table 11) subsequently proposed a provisional miospore zonation of the Horton Group, comprising seven lettered zones from A to G. In terms of this zonation, the Horton Bluff, Cheverie and Albert Formations contain Zone G miospores, and the Horton Bluff at its base contains Zone F miospores (Hacquebard, 1972, Fig. 4). Also, Greiner (1974, p. 1109) reported Late Devonian fish from the base of the Albert Formation. According to Barss (*in* Hacquebard, 1972, p. 73, Table 11), Zone G is latest Tournaisian although Barss and Hacquebard (*in* Hacquebard, 1972, p. 71, Table 1) suggest that it may extend into the earliest Viséan.

In summary, an Early Carboniferous, latest Tournaisian to earliest Viséan (= Early Mississippian) age is strongly indicated by the fossil plants and fish collected from the upper part of the Snakes Bight Formation, because they favorably compare with those contained in the Horton Bluff and Cheverie Formations (Horton Group) of Nova Scotia and the Albert Formation of New Brunswick. This information is summarized in Figure 2.

PALEOENVIRONMENTAL SIGNIFICANCE OF THE COLLECTED FLORA AND FAUNA

Unfortunately, the fossil plants and fish do not by themselves indicate whether the Snakes Bight Formation is of marine or nonmarine origin. Many of the plants collected in the field were fragmentary and current-oriented, suggesting that they have been transported. Of the fish present, *Acrolepis* appears to be mostly a marine genus. However, Traquir (1877-1914, p. 111) reports one species, *A. hopkinsi*, as occurring in both estuarine (freshwater to brackish) and marine beds. Three of the fish genera, *Canobius*, *Elonichthys* and *Rhadinichthys* occur mostly in freshwater deposits, but Traquir (1903, p. 692) and Schram (1983, p. 5,6) list species of these genera associated with definite marine fossils (i.e. articulate brachiopods, cephalopods, echinoderms, etc.).

Knight (1983) has already pointed out the lithological similarity of the Snakes Bight Formation to the lacustrine Albert Formation of New Brunswick (Greiner, 1962, 1964) and the lacustrine middle argillaceous member of the Horton Bluff Formation of Nova Scotia (Carroll et al., 1972; Hesse and Reading, 1978). This, coupled with the fact that no marine invertebrate fossils have yet been found in the Snakes Bight Formation, particularly within the carbonate lithofacies F of Knight (1983), suggests that this formation is probably a freshwater lacustrine deposit, as concluded by Knight (1983, p. 33).

ACKNOWLEDGEMENTS

P.L. Dean, J.R. Meyer, A. Best and D. Andrews are congratulated for their discovery of the first complete fossil fish in Newfoundland. B. and D. McHale (Tillicum Resources Ltd.) are thanked for

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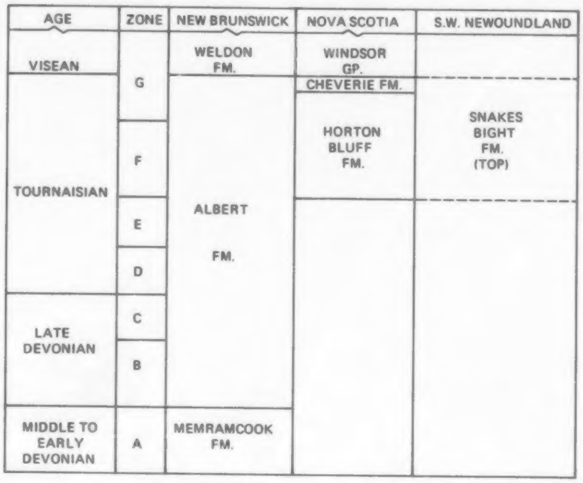

Figure 2: *Biostratigraphic correlation chart showing possible age range for the top of the Snakes Bight Formation (within the dashed lines). Miospore zones are those of Barss (in Hacquebard, 1972). Biostratigraphic correlation of New Brunswick and Nova Scotia lithostratigraphic units after Hacquebard (1972) with modification after Greiner (1974).*

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WEST COAST SHALE PROJECTS

by

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Two shale surveys were carried out in western Newfoundland during the 1984 field season. In the Corner Brook area, a search was carried out in conjunction with North Star Cement Company to locate new shale reserves which would be geochemically compatable with limestones used in the production of cement. In the Codroy-Anguille area, a lithogeochemical survey was carried out to continue the investigation of base metal potential in the Mississippian Anguille Group.

Corner Brook Shale Survey

The North Star Cement Company quarries shale adjacent to its cement plant in Corner Brook. Shale comprises 20% of the raw mix used in the making of cement and the existing shale quarry presents problems because of its variable geochemistry. A reconnaissance survey of Paleozoic shales was carried out to locate new potential shale reserves close to the plant.

A number of geochemical parameters restrict the type of shale used in the production of cement. They are (1) an $SiO_2:Al_2O_3$ ratio greater than 4:1, to assure long term strength of the cement, and (2) low levels of MgO, SO_3, K_2O and Na_2O. To avoid the buildup of undesirable residue in the kiln, a sulphur content below 1% is necessary to prevent the formation of sulphates by reaction with alkalai elements.

North Star's present and preferred shale geochemistry is shown in Figure 1 with the ranges of some of the elements in brackets:

North Star Shale		Ideal Shale
SiO_2	57% (53-65%)	60-65%
Al_2O_3	15% (11-21%)	10%
Fe_2O_3	5.5% (4-7%)	Not critical
MgO	3.8%	As low as possible
K_2O	2.8%	As low as possible
SO_3	1.3%	As low as possible
Na_2O	1%	As low as possible
S	1%	1% maximum

Figure 1

North Star counters the effect of the variable geochemistry of their shale pit by using a preblended stockpile. To attain the desired high silica content, unconsolidated siliceous sand is added to their mix, although grinding problems place a limit on the amount of sand which can be added. Location of a more consistent silica-rich, alumina-poor shale facies would not only facilitate day to day operations, but would allow greater flexibility in the production of various speciality cements.

Fine grained clastic sediments were sampled from 5 formations ranging in age from latest Precambrian to Carboniferous and representing several contrasting depositional environments. The geochemical composition of these units (Figure 3) are equally contrasting providing a varied selection of shale geochemistry and data which may modify some of the present geological contacts in the Corner Brook area. North Star analyzed the samples with their XRF unit as the project was being carried out, thus allowing for immediate follow-up of the most promising results.

The first group of "shales" studied belong to the Humber Arm Supergroup. Samples were collected from roadcuts on the Corner Brook "ring road" and on the north and south side of the Humber Arm (Figure 2). Lithologies sampled include red and green slates and gray to black fissile shales and interlaminated siltstones from the Summerside and overlying Irishtown Formations. These rocks are believed to have accumulated as a wedge of continental slope/rise sediments to the east of Lower Paleozoic shelf carbonates over which they were later thrusted during the Taconic Orogeny (Williams et al., 1982). Analyses of shales from these two units show that they are chemically very similar, but distinctively different than the shale from North Star's present quarry (see Figures 1 and 3). The $SiO_2:Al_2O_3$ ratios of less than 3:1 make the shales from these formations unsuitable for use in the production of cement.

The uppermost group in the carbonate shelf sequence is the Table Head Group. Near the top of this group there is a unit of black, pyritiferous shale/mudstone, the Black Cove Formation, whose type section is exposed on the coast just north of the Port au Port Peninsula. The shales were deposited in a restricted basin after the collapse of the Lower Paleozoic carbonate platform during the Middle Ordovician (Klappa et al., 1980). Sediments of this formation closely resemble those seen in the North Star's quarry but analyses are not available for geochemical comparison at this time.

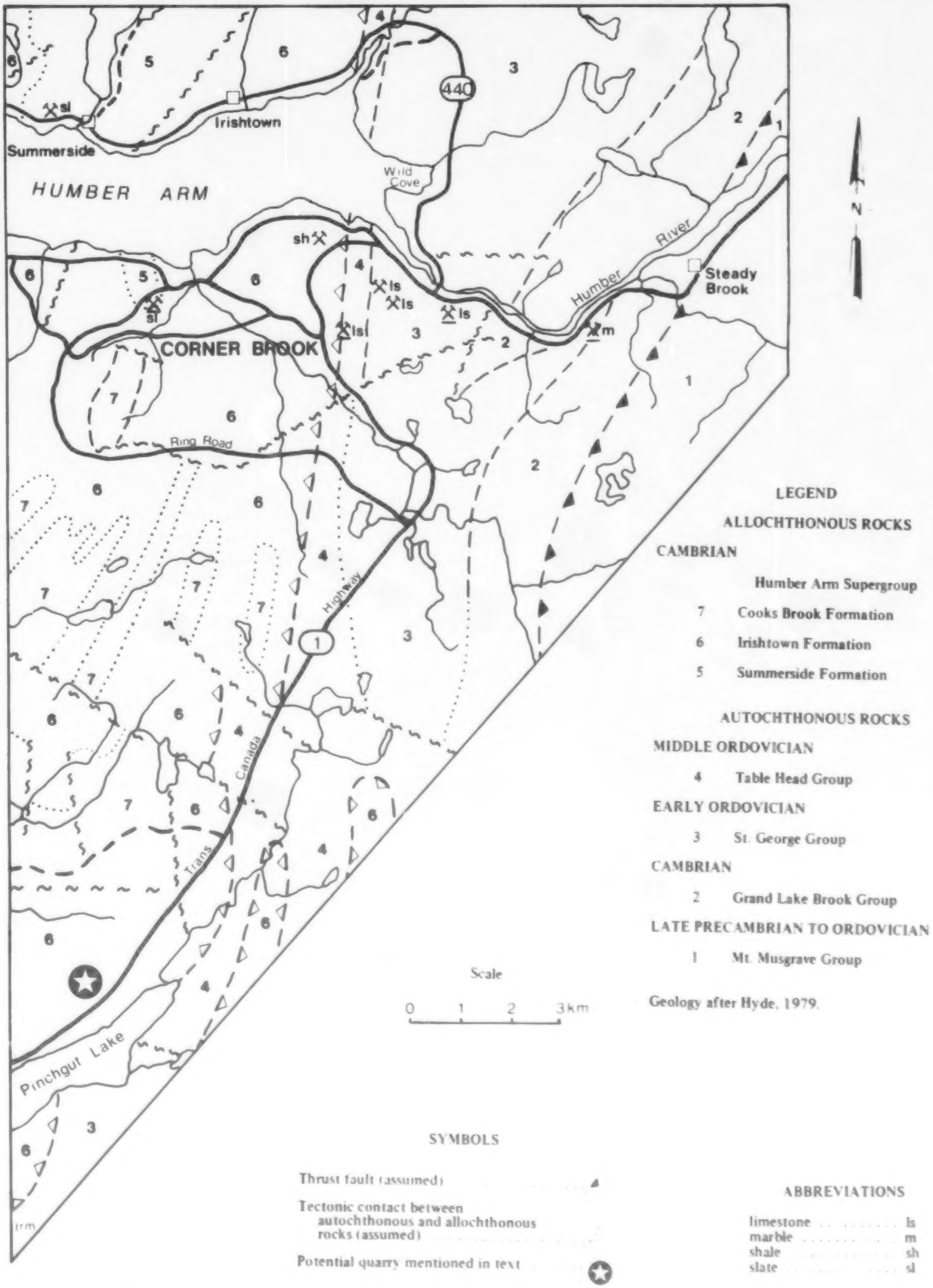

Figure 2: *Geology of the Corner Brook area.*

FORMATION	SiO_2	Al_2O_3	Fe_2O_3	CaO	SO_3	MgO	K_2O	TiO_2	Number of samples averaged	SiO_2:Al_2O_3
Summerside	52.3	18.7	7.0	0.7	0.1	3.5	3.3	0.8	4	2.80:1
Irishtown	49.8	20.3	6.9	1.5	0.3	3.4	2.8	0.8	22	2.45:1
North Star shale (Black Cove ?)	57.0	15.0	5.5	-	1.3	3.8	2.8	-	average from North Star	3.80:1
Green shale and sandstone	52.7	13.9	6.3	4.3	0.1	5.1	2.3	0.6	26	3.79:1
Rocky Brook	38.9	10.3	4.5	9.7	0.3	10.4	0.5	2.1	7	3.77:1

Figure 3

A third shale unit was sampled south of Corner Brook in the vicinity of Pinchgut Lake. Here, greenish to blackish gray, slightly chloritic shales interbedded with greenish gray schistose siltstones and sandstones outcrop on the west side of the Trans-Canada Highway and in an abandoned quarry to the southwest. While these sediments are distinctly different in appearance from those seen in North Star's quarry, their SiO_2:Al_2O_3 ratio is comparable, although the SO_3 and K_2O content is lower. On the basis of these results North Star began a small drill program in the abandoned quarry during the fall of 1984. Preliminary trace element analyses show that the average nickel content from this unit is 94 g/t, as compared to 38 g/t and 37 g/t from the Summerside and Irishtown Formation respectively, suggesting the chloritic shales are probably not correlative with the allochthonous formations. The high Ni content may, however, suggest the chloritic shales are autochthonous easterly derived flysch deposits of Middle Ordovician age perhaps equivalent to the Mainland sandstone of Schillereff and Williams' (1979). This formation has not been previously recognized in the Corner Brook area.

The youngest sediments investigated in this survey belong to the early Carboniferous Rocky Brook Formation which is exposed to the north of Deer Lake. Gray to black bituminous mudstones and greenish gray calcareous and/or pyritic shales deposited in a perennial lacustrine setting (Hyde, 1981) were sampled from roadcuts, stream exposures, and drill core. These sediments are comparatively lower in SiO_2 and Al_2O_3 than the other shale units sampled but have an average SiO_2:Al_2O_3 ratio of 3.77:1. The MgO content greater than 10% however, makes these shales unsuitable for the manufacture of cement.

From the geochemical data collected in this survey, the most favourable exploration targets for shale to be used in the production of cement in the Corner Brook area, would be: 1) recessively weathered shales of the Black Cove Formation, (near the upper contact of the Table Head Group in Figure 3), and 2) green chloritic shales and interbedded sandstones that outcrop south of Corner Brook.

Codroy Project

An investigation of the mineral potential of shale units of the Anguille Group in the Codroy-Anguille area was carried out in June, 1984. Shales and associated fine grained clastic sediments were sampled from the type sections and well exposed mineralized sections of the Mississippian Anguille Group. Base metal showings have been well documented in this area by Knight (1983) and Howse (1983). The mineralization is commonly associated with calcite and/or quartz veins which transect black shale of the Snakes Bight Formation. Knight (1983) suggested that mineralization found in small faults, tension joints and fractures was precipitated from fluids derived from the compaction and dewatering of this shale.

The Anguille Group consists of nonmarine sediments of late Devonian to early Carboniferous age. The sediments were deposited within a successor basin that evolved into a narrow fault bounded graben (approximately 30 km wide) that paralleled the Long Range Fault and shallowed to the northeast. Over 3 km of red and gray fluviatile sandstone, conglomerate and slate (Kennels Brook Formation) were initially laid down in the late Devonian. Wrench fault movement, initiated in the early Carboniferous along the Long Range Fault, controlled the formation of a pullapart basin and uplifted highlands around the basin. Deep to shallow water lacustrine sediments of the 1 km thick Snakes Bight Formation were deposited at this time in the wrench graben. The lake shallowed with time and became restricted to the southwest of the basin as gray fluvial deltaic and red fluvial sands and muds of the Friars Cove and Spout Falls Formation filled the basin. The main locus of subsidence within the basin at this time shifted to the northeast coupled with the displacement of highlands to the north of the basin (Knight, 1983).

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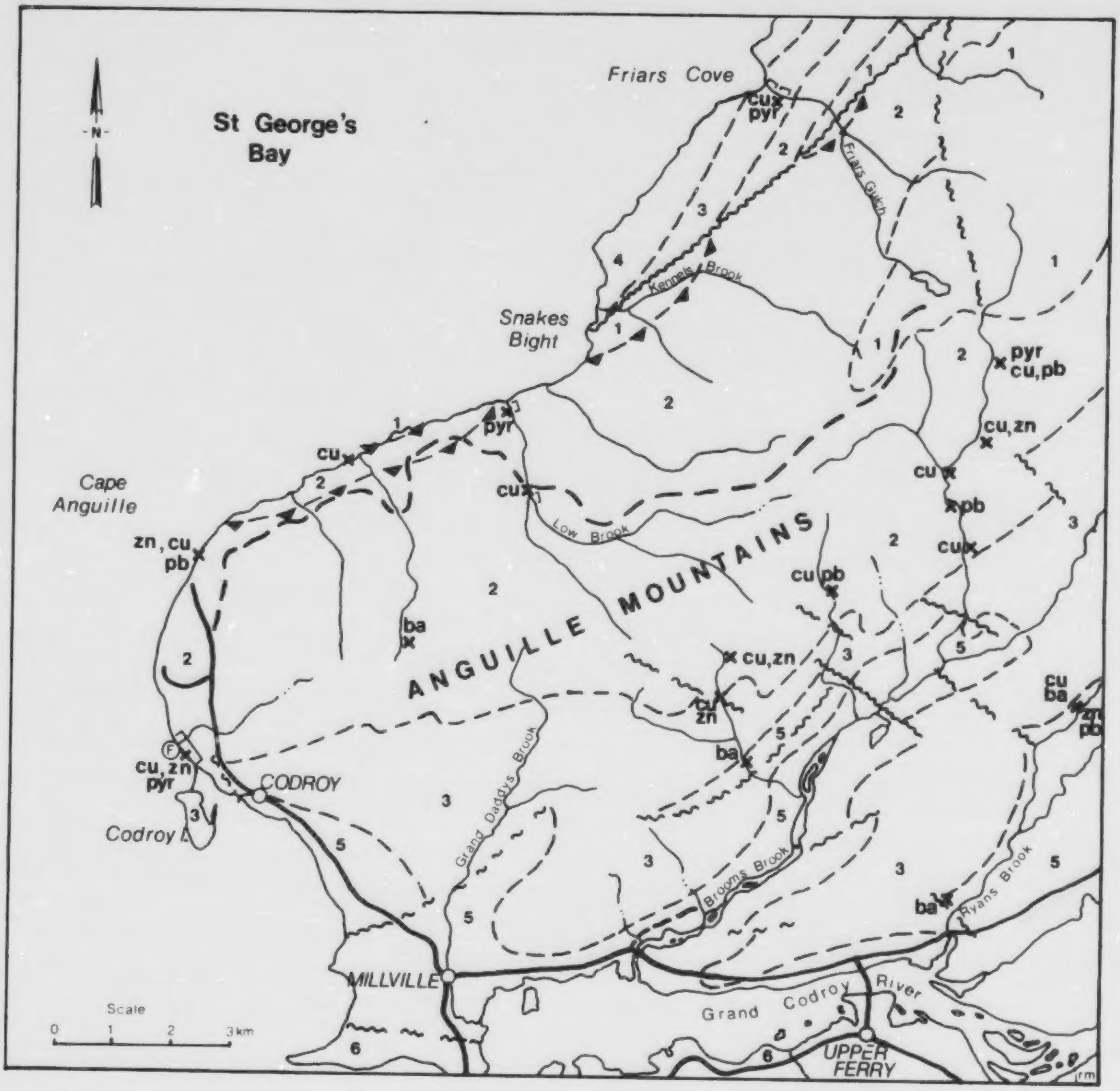

LEGEND

6 BARACHOIS GROUP (Namurian to Westphalian)
5 CODROY GROUP (Middle to Upper Visean)
ANGUILLE GROUP (Tournaisian, may include Fammenian)

(Units 1-4)
4 SPOUT FALLS FORMATION
3 FRIARS COVE FORMATION
2 SNAKES BIGHT FORMATION
1 KENNELS BROOK FORMATION

SYMBOLS

Geological Boundary (approximate) —-—
Fault (definite, approximate, assumed)
Thrust Fault (approximate) —▲—
Mineral Occurrence ✕ zn
Fossil Fish Ⓕ
Section ⌐

ABBREVIATIONS

Barite......	ba	Pyrite......	pyr
Copper......	cu	Zinc........	zn
Lead........	pb		

Geology from Knight and Brown, 1975.

Figure 4: *Geology of the Codroy-Anguille area.*

Sediments at the base of the Snakes Bight Formation consist of lacustrine black shale and mudstone which are often finely laminated, pyritiferous and carbonaceous, indicating euxinic basin conditions. The lake was subsequently infilled with density current deposits that produced a variety of sandstone, siltstone, and shale lithofacies. Thick mixtite units punctuate deposition and suggest that the basin had steep unstable flanks and was tectonically active. Growth faults, notably the Snakes Bight Fault (Figure 4) were active at this time. Characteristics found in the Snakes Bight Formation compare favourably to the geological setting of known sediment-hosted massive sulfide deposits described in a review by D. Large (1983). This survey will attempt to document whether any rocks of the Snakes Bight and Friars Cove Formations have an anomalously high background in base metals and possess the potential for economic concentrations of such metals.

Three sections were mapped and sampled from the Snakes Bight Formation. Two of these are on Low Brook, which drains into St. George's Bay at Snakes Bight. The first is at the mouth of Low Brook and the second is upstream of the road to the site of the abandoned Brinex Union Oil oil well site (Figure 4). The third is a coastal section northwest of the breakwater at the town of Codroy. Each section contains two or more of the following styles of mineralization: (1) stratiform pyrite laminations up to 4 mm thick; (2) finger-sized "clots" of disseminated pyrite/chalcopyrite; (3) veinlets of pyrite and/or chalcopyrite, and (4) sphalerite crystals (1-4 mm in size) in calcite veins and/or galena crystals (1-3 mm in size) on calcite-coated fracture planes. Further work in this formation included prospecting and sampling short and long sedimentary sections on the northernmost tributary of Brooms Brook, where Howse (1983) previously found showings of chalcopyrite and galena. In the Codroy breakwater section a complete, well preserved fish fossil was found, the first non-marine vertebrate fossil found in the Anguille Group (see Boyce et al., this volume).

Two shale sections within the Friars Cove Formation were sampled at the type section on Friars Gulch (Figure 2). Both contain 1-3 mm pyrite laminations in shale, finely disseminated chalcopyrite in both interlaminated siltstone and in 5-10 mm rounded "clots" in sandstone interbeds. As in the Snakes Bight Formation much of the shale sampled is black, finely laminated, carbonaceous and sulphide-rich, although gray shales also occur in the sections.

In total 77 chip samples were collected from 1 to 3-metre stratigraphic intervals and are presently being analyzed for Cu, Pb, Zn, Ag, Ba, Fe, Mn, Ni, Co, V, U, F, and major elements.

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GEOLOGICAL MAPPING OF CAMBRIAN AND ORDOVICIAN SEDIMENTARY ROCKS OF THE BELLBURNS (12I/5/6), PORTLAND CREEK (12I/4) AND INDIAN LOOKOUT (12I/3) MAP AREAS, GREAT NORTHERN PENINSULA, NEWFOUNDLAND

by

Ian Knight

ABSTRACT

Lower Paleozoic platformal, flyschoid and allochthonous rocks occur in the map area. Lower Cambrian siliciclastics and carbonates and Middle Cambrian to Middle Ordovician carbonates compose the generally conformable platformal sequence that sits unconformably upon Precambrian granitic basement. Regional subaerial exposure of the platform during sedimentation produced two disconformities at the middle and end of the Lower Ordovician. Paleokarst developed at the surfaces and a network of stratiform and discordant collapse breccias formed at selective lithostratigraphic horizons and close to northeast trending faults.

The platform plunges south beneath Middle Ordovician northeastward and eastward derived sandy flysch. Spectacular limestone breccias derived from destruction of uplifted Middle Ordovician platformal carbonates occur within the flysch. Allochthonous rocks include ribbon limestones and shale and limestone conglomerates and thin bedded fine grained sandstones and shales of unknown age.

The gently to moderately dipping autochthonous strata are transected by numerous long northeast trending and an important group of west trending faults. The Long Range Precambrian inlier is thrust westward over autochthonous strata. A narrow zone of strong deformation and extensive recrystallization of the carbonates occurs in platformal rocks west of the thrust. Inverted bedding, recumbent folds and thrust and reverse faults occur in the zone.

Numerous sphalerite showings occur in dolomites that replace Lower Ordovician limestones in the center of the area. The carbonate hosted Mississippi-valley type deposits form a zinc rich district centered around the Daniels Harbour Zinc Mine.

INTRODUCTION AND GEOLOGICAL SETTING

A large southward-narrowing wedge-shaped area of Cambrian and Ordovician platformal rocks was mapped between River of Ponds and Parsons Pond on the west side of the Great Northern Peninsula (Figure 1). The rocks include gently dipping to strongly deformed strata of the Lower Paleozoic autochthonous Humber Zone, which formed the northern Newfoundland part of the passive margin of Iapetus Ocean. These rocks lie west of uplifted Precambrian basement rocks of the Long Range Mountains and their outcrop narrows to the southwest as they plunge beneath autochthonous Middle Ordovician flyschoid formations and transported Lower Paleozoic deepwater sedimentary rocks of the northern edge of the Humber Arm Allochthon. The Lower Paleozoic autochthon lies unconformably upon Precambrian basement; this contact can be observed only in the northeastern part of the Bellburns map area on and near Blue Mountain.

The autochthonous sequence is essentially a conformable, platformal buildup. However, two intervals of erosion of middle and late Early Ordovician age occur within the carbonate succession. In the Middle Ordovician, the platform collapsed and was blanketed by thick Middle Ordovician flysch derived by erosion of Lower Paleozoic allochthons that were subsequently obducted onto the autochthon during the final phases of the Taconic orogeny. Severe folding and faulting affected the rocks that form the structurally lower parts of the Taconic allochthon. Deformation of the autochthon mainly resulted in many north to northeast and eastward trending faults but, close to the allochthon and near the uplifted Long Range Precambrian inlier, the platformal rocks are much more intensely deformed. The area provides an excellent opportunity to study the faulted contact relationships of the Long Range inlier and the Lower Paleozoic platformal rocks.

Field mapping was done along the Viking Highway, along extensive wood roads, and around many lakes to facilitate access by foot to all but the eastern areas near the Long Range Mountains, where a helicopter was used. Recently regenerated to mature evergreen forests and huge tracts of peat land, particularly in the western and southern parts of the area, characterize the low (60 to 180 m) coastal plain in the area. Only close to the Long Range Mountains, which overlook the plain at an elevation of 360 to 460 m, does topographic relief become rugged. Here, scarp-edged,

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

LEGEND

SEDIMENTARY ROCKS OF UNKNOWN AGE, POSSIBLY ALLOCHTHONOUS

Sh - *Green, gray, black shale and mudstone, thin limestone, thin sandstone, red and black chert.*

Cgl - *Limestone conglomerate, thin bedded limestone, shale, minor sandstone.*

AUTOCHTHONOUS ROCKS

MIDDLE ORDOVICIAN

Ss-2 - *Unnamed upper green sandstone, pebbly sandstone, conglomerate, shale.*

Ls-Br - *Unnamed limestone breccia and minor calcarenite.*

Ss-1 - *Unnamed lower green sandstones and interbedded shale, some pebbly sandstone.*

TH Table Head Group - *Limestone, minor dolomitic limestone, dolostone and shale.*

TH-2 - Table Cove and Black Cove Formations
TH-1 - Table Point Formation; THd - dolomitized

LOWER ORDOVICIAN

St. George Group (SG, WB, BH, C, A)

SG - Undivided

A Aguathuna Formation - *Dolostone, dolomitic shale, chert pebble conglomerate and pebbly dolostone.*

C Catoche Formation - *Limestone, C_l, top extensively replaced by diagenetic dolostone C_d.*

BH Boat Harbour Formation - *Limestone, dolomitic limestone, dolostone, diagenetic dolostone, collapse breccias.*

WB Watts Bight Formation - *Diagenetic dolostone.*

MIDDLE TO UPPER CAMBRIAN

Port au Port Group (PP, MP, PJ)

PP Undivided

PJ Petit Jardin Formation - *Dolostone, minor shale and limestone.*

MP March Point Formation - *Dolostone, minor shale, sandstone.*

LOWER CAMBRIAN

Labrador Group (L, B, F, HB)

L Undivided

HB Hawke Bay Formation - *White sandstone, minor shale.*

F Forteau Formation - *Limestone, shale, sandstone.*

B Bradore Formation - *Red and gray sandstone, minor conglomerate.*

PRECAMBRIAN

PE Grenville Basement - *Granite, gneiss.*

SYMBOLS

sp Sphalerite ______________________ ⚒sp
sp Sphalerite boulders ______________________ ○sp

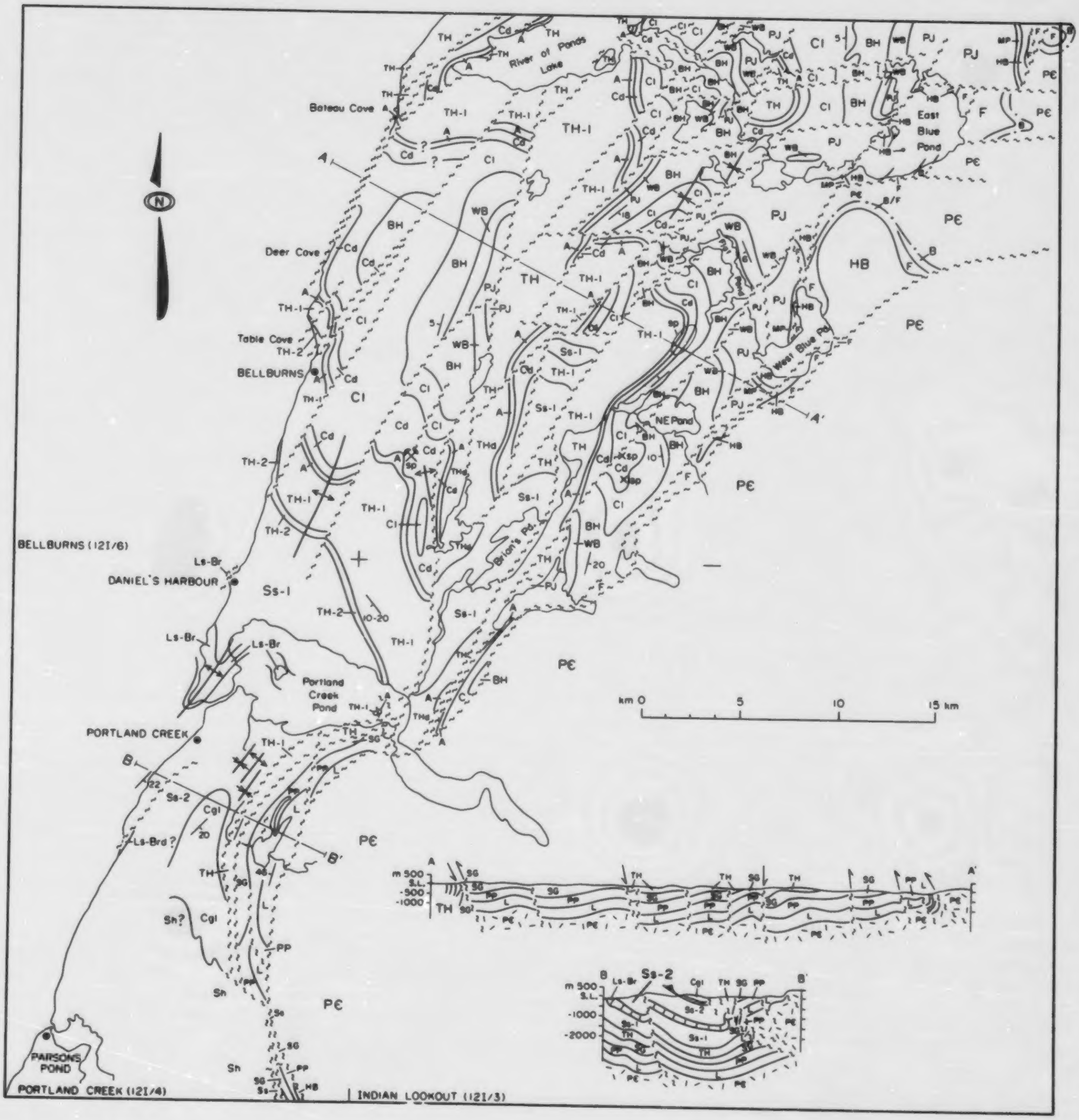

Figure 1: *Sketch map of the geology (in part), of the Bellburns, Indian Lookout and Portland Creek map sheets.*

north trending ridges and lake-filled valleys reflect the 3 km wide, folded and faulted zone of underlying platformal rocks.

The area is well known for the zinc mine at Daniels Harbour. The Mississippi Valley-type sphalerite mineralization in several closely grouped deposits forms the heart of this zinc-rich district.

STRATIGRAPHY

Three geologic terranes occur in the map area; namely, Precambrian basement, autochthonous Lower Paleozoic platformal and basinal sedimentary rocks and allochthonous Lower Paleozoic basinal sedimentary rocks.

Precambrian Basement Rocks: Uplifted Precambrian basement rocks form the Long Range inlier at the eastern edge of the map area. These rocks, mapped only in a reconnaissance fashion for less than 2 km east from their western contact, consist predominantly of massive, slightly foliated, equigranular, fine to coarse grained to megacrystic, pink to red, micaceous granites. Rafts and layers of hornblende-plagioclase and quartz- feldspar-mica gneiss are enclosed within the granites. Chlorite is ubiquitously developed through the granite, suggesting that the basement rocks have undergone greenschist grade metamorphism. Foliations measured in the outcrop generally dip at low to moderate angles to the east.

Lower Paleozoic Platformal Rocks: Lower Paleozoic platformal rocks approximately 1600 m thick in the map area are subdivided according to the nomenclature outlined previously in adjacent map areas by Knight and Boyce (1984). Additional nomenclature follows that of Klappa et al. (1980) for rocks of the Table Head Group. The succession is described in order of the four rock groups that comprise the platformal succession; namely, the Labrador, Port au Port, St. George and Table Head Groups.

Labrador Group (Lower Cambrian): This mixed siliclastic-carbonate succession comprising the Bradore, Forteau and Hawke Bay Formations is exposed only along the eastern edge of the map area. There, it forms either fault-bounded wedges that are steeply dipping to overturned just west of the Long Range boundary fault or flat-lying, rounded to arrowhead-shaped outliers resting unconformably upon Precambrian basement rocks, as on and just north of Blue Mountain.

The succession is best exposed in a steep gulch on the northwest side of Blue Mountain, where it consists of poorly exposed basal pebbly, red arkosic sandstones of the Bradore Formation (1a) overlain by thinly stratified gray, micaceous, sandstones and shales. These are capped by planar laminated and thinly stratified and crossbedded, slightly bioturbated red arkosic sandstones, similar to those described in other Long Range outliers of the Torrent River map area (Knight and Boyce, 1984).

A pink, crystalline dolomite(?) to nodular, shaly fossiliferous gray limestone conformably rests upon the topmost red sandstones of the Bradore Formation. It is correlative with the Devils Cove Member, Forteau Formation, Canada Bay and elsewhere in western Newfoundland (Knight and Saltman, 1980; James and Kobluk, 1978; James and Stevens, 1982). The remaining 110 m of the Forteau Formation (1b) consists of fossiliferous black shales that contain thin bioclastic limestones overlain by crossbedded and stratified, bioclastic and oolitic black limestones. The limestones are interbedded at intervals with cross laminated and laminated, often strongly bioturbated gray siltstones and shales. No evidence of archaeocyathid bioherms has been noted in the map area.

Resting conformably upon the Forteau Formation, are white to pinkish and massive weathering, flinty, white quartz arenites of the Hawke Bay Formation (1c) that form the contour-bedded tops of the outliers. The well sorted, unfossiliferous quartz arenites are crossbedded and commonly ripple marked, but are conspicuously bereft of bioturbation. This is in contrast to several intercalated units, 1-4 m thick, of thinly bedded, planar laminated and cross-laminated, argillaceous and shaly, gray and red quartzose sandstones. These are intensely ploughed by numerous u-shaped and tubular burrows and may contain layers of phosphatic intraclasts. Phosphate crusts on sandstone beds and phosphate, shale and sandstone intraclasts particularly characterize 10 cm thick, cross-laminated and laminated, sandstones that are interbedded with gray shales in a 2 to 3 m thick sequence at the top of the formation.

The characteristics of the Labrador Group support the interpretation of the depositional history of the group in nearby areas as proposed by Knight (in preparation). Braided stream sands deposited on a coastal plain, that lay west of a shallow siliciclastic shoreline, contributed the red and gray sandstones of the Bradore Formation. Widespread transgression established open marine shelf conditions in which accumulated the shallowing upward, low energy shale and high energy, grainy limestone succession of the Forteau Formation. Eastward prograding quartz sands blanketed the carbonate shelf in a complex of tidal sand bodies and related intertidal facies, as the Hawke Bay Formation completed the succession. Abundant phosphate intraclasts and crusts at the top of the formation suggest exposure of the platform as sedimentation on the Early Cambrian shelf came to an end.

Port au Port Group (Middle to Late Cambrian): A poorly exposed succession of argillaceous dolostones, dolostones, shales and limestones forms the Port au Port Group. The basal March Point Formation (30 m) (2a) rests with sharp conformity upon the Hawke Bay sandstones. This formation consists of basal dark gray shales overlain by yellow weathering, bioturbated and vuggy, thinly stratified, dark gray argillaceous dolostones. Green, gray and reddish shales, yellow weathering, pale gray dolostones, and gray to blue-gray limestones comprise the overlying Petit Jardin Formation (2b). The shales are mostly low in the formation, intercalated with dolostones that exhibit cryptalgal structures and many other features of intertidal and supratidal carbonate flat deposition. Limestones and dolostones are important in a middle member that contains stromatolites, channel-bound and sheeted intraformational floatstones and rudstones, oolitic grainstones, burrowed, thinly bedded and parted limestones and muddy dolomitic carbonates as well as mudcracked horizons. Trilobites recovered from the member in two localities along the west shore and 1.4 km west of Western Blue Pond (known locally as John William's Bluey) include *Arapahoia* sp., *Coosella* sp. cf. *C. helena* Lochman, *Terranovella* sp. cf. *T. obscura* Lochman and *Welleraspis* sp.; they are indicative of the Dresbachian *Crepicephalus-Cedaria* zones which suggests the unit spans the early Late Cambrian (Boyce, this volume).

Buff weathering, thickly bedded, cherty dolostones form most of the upper half of the formation. Burrowed and stromatolitic beds alternate with wavy laminated and thinly bedded microcrystalline dolostones.

The rocks of the Port au Port Group accumulated within shallow subtidal to supratidal carbonate settings. Tidal flats accumulating cryptalgal laminites and mudrocks were established as deposition of the Petit Jardin Formation succeeded the shallow subtidal muds that formed much of the March Point Formation. Higher energy stromatolite buildups, fringed by oolite bodies, and tidal flat deposits crossed by conglomerate-filled tidal channels typify the middle of the formation. More open shelf conditions then produced repeated shoaling upward peritidal sequences, suggesting repeated migration of shallow shoreline conditions as mudflats or mudflat islands prograded seaward over subtidal or lagoonal muds.

St. George Group: The Lower Ordovician St. George Group is widely developed in the central, western and southern parts of the map area. It has been subdivided into four formations outlined previously by Knight and Boyce (1984) and Knight (in preparation) in the Port Saunders area. Lithologically, the basal Watts Bight Formation (3a) is composed of black, fine to medium crystalline diagenetic dolostones exhibiting extensive burrow-mottling of thinly stratified carbonates and lesser cryptalgal mounds; it remains consistent as elsewhere on the Northern Peninsula. It is best exposed around the western part of Eastern Blue Pond (locally called Western Bluey) and near Flat Pond. The overlying Boat Harbour Formation (3b) is not well exposed; it consists of a complex array of interbedded limestones, dolostones, shaly limestones, and diagenetic dolostones. Features of shallow peritidal deposition such as fossiliferous, bioturbated mudrocks, associated stromatolites, flaser bedded and laminated, locally mudcracked, dolomitic limestones were noted in better outcrops.

Highlighting the 1984 mapping in this formation, however, was the discovery of several exposures of the Boat Harbour "pebble bed" and exposure surface along the coast and along a woods road near Bateau Barrens. This interval, which occurs less than 30 m from the top of the formation where it is overlain by cyclically developed grainy and muddy limestones, is expressed slightly differently in the various localities. However, it is always typified by the presence of abundant chert that fulfills a replacing and cementing role within carbonates below the solution surface and is reworked as pebbles in the overlying beds. In the roadside outcrop, the pebbles are scattered in a 60 cm thick conglomerate also containing dolostone and limestone pebbles. In exposures along the shore at Bateau Barrens, chert pebbles are concentrated in the overlying bed and in pockets and fissures along the irregular exposure surface. The chert is typically oolitic, porcelaneous or white megaquartz. Silicified fossil fragments occur in the roadside outcrop within the conglomerate.

Dolomitization of underlying strata also occurs up to a metre thick in the roadside exposure where there are no later dolomite overprints. In the coastal sections, however, dolomitization is considerably thicker, but this is likely related to dolomitization within a complex fault zone that follows the coast from Bateau Barrens south to Deer and Freshwater Coves. There is no relief or evidence of solution in the roadside outcrops, but relief of tens of centimetres occurs in the coastal sections. Also present in the coastal exposures are narrow branching hardrock fissures penetrating a few metres below the exposure surface as well as locally developed pockets of solution collapse breccias. Both are filled by a microcrystalline, vitreous black dolomite matrix or cement. Metre thick, concordant, stratabound breccias composed of blocky, dolostone fragments up to 20 cm in size and set in a black siliceous dolostone and small rock particle matrix also occur in the same coastal fault zone at the southern end of Bateau Barrens. This breccia rests upon black Watts Bight dolostones and is comparable to other similar breccias that occur in the same stratigraphic interval elsewhere on the Northern Peninsula (Knight, 1978, 1980, in preparation; Knight and Boyce, 1984).

The overlying Catoche Formation (4c) is a succession of well bedded, bioturbated and fossiliferous, gray limestones which are replaced extensively by secondary dolostones towards the top of the formation. The limestones consist mostly of wackestones and packstones that are argillaceous and unevenly thinly stratified; lenses of intraclastic and bioclastic mudstones and planar stratified and rippled marked grainstones also occur. Boundstone mounds occur towards the base of the formation. The secondary dolostones are gray to black, massive, vuggy, and fine to medium crystalline. Open spaces filled by white baroque dolomite occur in selected beds known as pseudobreccia. Limestones are interbedded with and pass laterally into the dolostones towards the top of the formation.

Buff to yellow weathering, microcrystalline, light to dark gray, dolostones and green dolomitic shales of the Aguathuna Formation (4d), form the top of the St. George Group. Lamination, cross-lamination, small tepee structures, intraformational breccias, and mudcracks typify the dololaminites that intercalate with burrow-mottled, and thinly bedded dolostones, and rarely stromatolitic dolostones. Sand and pebbles composed of chert and dolostone lithoclasts also occur in the upper 12 m of the formation where they form layers, a few centimetres thick, in planar laminated dolostone towards the base of shallowing-upward cycles. A number of crudely stratified beds, 40 cm to 3 m thick of chert-dolostone pebble conglomerate, again in the upper 12 m of the formation, occur on the north shore of River of Ponds Lake, the eastern island of Portland Creek Pond and in a fault-bounded wedge along the shore at Table Cove, Bellburns. Silicification, fracturing, post-depositional brecciation and irregular bedding surfaces occur near and below the chert pebble interval in the formation.

There is a major thickness difference of 45 m between sections in the Aguathuna Formation on the northwest (15 m) and northeast (60 m) shore of River of Ponds Lake. This suggests that major faults that transect the lake (Torrent River Fault) have either juxtaposed two different paleogeographical settings or were active during deposition of the formation. At the base of the thinner section, Aguathuna dolostones rest upon a very irregular surface with relief up to 40 cm sculptured in diagenetic dolostones of the Catoche Formation. Silicification and fracturing is common below the surface; depressions at the surface and cavities and fissures below are filled by Aguathuna dolostones and chert detritus.

A coherent part of the Aguathuna Formation are matrix breccia bodies such as described by Lane (1984). The largest exposed rock body at Mine Lake is several hundreds of metres across and contains variable bedding punctuated by zones of mostly dolostone rubble. However, a breccia zone composed of color banded, laminated and thin bedded, black and light gray limestone occurs in the centre of the breccia body that cuts down into the underlying Catoche dolostones and limestones.

Numerous oligo- and polymictic matrix breccia bodies lie along the trace of the Bateau Cove fault zone where it cuts dolomites of the middle of the St. George Group. Abundant spar breccias also occur individually, and overlying and peripheral to matrix breccias. Matrix breccias are both concordant and discordant to bedding. Preliminary studies suggest some of these breccias post-date deposition of the Catoche Formation, while others have been linked to events affecting the older Boat Harbour Formation. Similar breccias have been noted in the Aguathuna Formation west of Eastern Blue Pond.

The buildup of the Early Ordovician platform was accomplished by deposition of generally monotonous subtidal limestone and repeated sequences of peritidal carbonate in two megacycles of transgression and regression. Both Tremadocian (Watts Bight - Boat Harbour Formations) and Arenigian (Catoche - Aguathuna Formation) megacycles culminated in subaerial exposure of the platform which was accompanied by widespread diagenesis, solution and development of a karst cavern system. Areal development of the subterranean cavern systems, now filled by collapse breccias, was controlled by lithostratigraphy and structure. Widespread stratabound collapse brecias are consistently located in basal dolostones of the Boat Harbour Formation immediately above the Watts Bight Formation. The cavern system related to the late Arenig disconformity however, was partly controlled by northeast trending faults and fractures that also influenced the thickness of the

Aguathuna Formation. They also formed the channel ways for deep penetration of solutions through the platform (Knight and Boyce, 1984).

Table Head Group (Middle Ordovician): The Middle Ordovician Table Head Group was defined by Klappa et al. (1979) as consisting of the Table Point, Table Cove, Black Cove and Cape Cormorant Formations.

The Table Point Formation is well known as a highly fossiliferous, well bedded, blue gray to gray, subtidal limestone. This year's mapping has, however, continued to highlight the formation's diversity. The formation commences with a basal cyclic member of bioclastic and intraclastic grainy mudrocks intercalated with laminated, frequently mudcracked, dolomitic lime mudstones or dolostones. This is overlain by a light gray weathering, fine grained, fenestral limestone. The fenestral limestone contains cement-filled skeletal porosity after gastropods and cephalopods as well as tubular and laminar fenestra and "stromataoids" voids, the latter filled by geopetal muds and calcite cements. Although this member is readily distinguished over wide areas of the map area where it can reach 30 m thickness, it is not present at Table Point and in the northeast of the map area where dark gray, mottled wackestones dominate the section. This suggests that there are rapid lateral facies changes; similar conclusions have been reached based on the study of drill logs in the Bellburns map area (Lane, personal communication, 1984).

Fossiliferous and bioturbated subtidal, argilliaceous dark gray limestones overlie the fenestral carbonates. Slump breccias and folds deform the subtidal limestones 3 m below a succession, 23 m thick, of interbedded burrowed, bioclastic wackestones and scour-based, cross laminated grainstones. Some small boundstone mounds also occur and the wackestones and grainstones intercalate upwards with dololaminites. The dololaminites exhibit lamination, cross bedding, mudcracks and fissure cracks, scour-and-fill structures, and pockets of intraformational breccia typical of intertidal settings. A succession of similar lithologies, 19 m thick, occurs in the middle of a westward younging, partly inverted sequence of Table Point Formation west of the Bateau Cove Fault, south of Bateau Cove. The remaining 200 + m of the formation consists of highly fossiliferous, bioturbated, argillaceous limestones that contain abundant large cephalopods, gastropods, sponges, bryozoa, ostracods, trilobites and brachiopods. Nodular to planar, thin bedded, argillaceous, lime mudstones with thin gray shale interbeds characterize the conformably overlying Table Cove Formation. The formation is famous for its Toquima - Table Head trilobite fauna (Ross and Ingham, 1970). Many beds in this formation are deformed by synsedimentary slump folds, thrust faults and rotational slides.

The Table Cove Formation is gradationally overlain by 17 to 27 m of black shales of the Black Cove Formation. A few discontinuous fine limestone beds occur at the base. The top of the formation is badly sheared at Table Cove where it is almost 10 m thinner than at a shoreline section opposite the Daniels Harbour mine road.

Limestone conglomerates intercalated with shales, limestones and sandstones, defined as the Cape Cormorant Formation by Klappa et al. (1980), do not occur in the map area. Limestone breccias occurring at Daniels Harbour, Cliffy Point and Eastern Head and the western island of Portland Creek Pond are believed to lie within a succession of green sandy flysch and are not included in the Table Head Group.

Lithofacies that comprise the Table Head Group were laid down in shallow peritidal to open shelf environments during the deposition of the Table Point Formation. Cyclical peritidal shoaling upward sequences of the basal member of the formation appear to be superceded by shallow water light-coloured, fenestral limestones. These accumulated possibly as dominantly intertidal carbonate mud mounds rich in fenestra and accreting adjacent to areas of shallow subtidal carbonate mud. Shallow sandy to muddy tidal flat carbonates that overlie these deposits were then blanketed by widespread subtidal shelf limestones that hosted a rich shelly fauna. Continued sea level rise drowned the platform margin leading to deposition of slope deposits of the Table Cove Formation and basinal shales of the Black Cove Formation.

Autochthonous Middle Ordovician siliciclastic rocks and limestone breccias: Green sandstones interbedded with black shales form a succession of turbidite sands of great but unknown thickness. The succession is essentially composed of metre-thick sequences of thick bedded sandstones, pebbly sandstones and conglomerates, regularly intercalated sandstones and shales, shales with thin sandstones and siltstones and rare shale-sandstone mixtites. Sandwiched in the middle of the formation is a remarkable sequence of limestone breccia composed of rubble and blocks of Table Head limestone mixed with large ripups of shale and green sandstone. Towards the top and overlying the breccias are some calcarenites composed of rounded limestone sand and granules. No contacts between the green sandstones and limestone breccias are exposed but, 1) the presence of sandstone lithoclasts, 2) the consistent structural position, and 3) the lack of evidence for faults that might have uplifted and tectonically disrupted Table Head Group, support the interpretation that the breccias lie stratigraphically within the flysch and not at the base. Dolomitized limestone breccias and limestone sandstones that form The Arches south of Portland Creek, may be equivalent to the breccias, later uplifted by a northeast trending fault. If this interpretation is true, then the sandstones and conglomerates forming Portland Hill possibly belong to the uplifted sequence and repeat rocks that occur near and south of Portland Creek.

The green sandstones display grading, massive, laminated and cross-laminated intervals typical of Bouma sequences, convolute bedding, vein networks of pillar structures, shale ripups, allochthonous shelly fossils, and flute and load casted bases. Many of the thicker beds contain pebbles of sandstone, shale, quartz, chert, argillite, light gray to white limestone, and are crossbedded. Conglomerates form a major part of the succession on top of Portland Head. They include pebbles up to 10 cm in size of massive to laminated, sometimes dolomitic, muddy, pale gray, limestone, some with quartz sand laminae, crinoidal grainstone, yellow weathering dolostone, rare black and red chert, green sandstone, and larger intraclasts of intraformationally derived conglomerate. The conglomerates form lenses and beds with sandstone matrices within dominantly green sandstones that are planar laminated or are affected by a gently eastward dipping foliation.

A mixtite composed of sandstone and shale intraclasts in a shale-sand matrix occurs towards the top of the coastal section, 2 km north of the Arches. The shale dominated sequences consist of finely laminated mudrocks intercalated with 1 to rarely 10 cm laminated and cross-laminated siltstone and sandstone beds.

Cross-lamination and crossbeds in the lower sandstones at Table Point suggest a prevailing southward direction of sediment transport. Crossbeds in sandstones near Portland Creek indicate a southwestward to westward paleocurrent direction.

The limestone breccia member of the formation is of unknown thickness although it is probably tens of metres thick. It consists of indistinct, roughly bedded, centimetre sized rubble enclosing blocks that may approach the dimensions of a small house. The lithoclasts in the breccia include limestones of Table Point and Table Cove Formation type as well as black and green-gray shales and green sandstones comparable to the Black Cove Formation and overlying sandstones. Exotic clasts include white fenestral laminated limestones with early geopetal fills and cements, bioclastic limestones and gray and white mottled boundstones. Larger blocks exhibit partial brecciation and buckling. Although most of the breccias lack significant mud matrix, one bed, several metres thick on the western island of Portland Creek Pond, contains limestone clasts floating in a shale matrix. At the top of the unit, in Portland Cove, the breccias are overlain by granulose to fine grained calcarenites composed of rounded gray limestone sand. They are well bedded, graded, crossbedded and internally convoluted. Channels within the breccias north of Eastern Head, are also filled with similar calcarenites that are partly eroded by overlying breccia.

The unnamed Middle Ordovician sandstones and limestone breccias are generally believed to have accumulated in a foreland basin following collapse of the Lower Paleozoic platform and east of advancing Taconic allochthons. The green sandy flysch, exhibiting sand and shale dominated sequences and varieties of turbidites and grainflows, probably formed upon deepwater fans. The lower sandstones and shales derived from the north, blanketed the collapsed carbonate platform. However, tectonic activity within the basin uplifted both sands and parts of the underlying platform which then disintegrated by mass wastage and possibly tectonic disturbance. Megabreccias accumulated in local areas of the basin superceded by finer limestone sand deposits as the uplifted platform highs were reduced in size and/or blanketed by the younger sequence of easterly derived sandy flysch.

Autochthonous or allochthonous sediments of unknown age or affinity: Limestone conglomerates, thin bedded limestones and shales with minor sandstones form an unnamed rock unit (map unit Cgl) on the ridge east of Portland Hill. The unit is at least structurally overlying the green sandstone of Portland Hill, but no contact was observed to prove stratigraphic continuity. A leafy, gently eastward dipping lamination occurs in the last observed outcrop of rotted green sandstone before the limestone conglomerate is encountered. This fabric may have been structurally produced however, had the limestone conglomerate been thrust over the sandstone. The limestone conglomerate unit has been mapped south of Five Mile Road. The succession is dominated by beds up to 4 m thick of pale gray, pebble- to matrix-supported limestone conglomerate composed of well sorted, rounded tabular limestone lithoclasts. The lithoclasts range up to 10 cm in size and include laminated and thin bedded lime mudstones and lesser oolitic and crinoidal grainstones. Some large limestone conglomerate intraclasts also occur. The conglomerates are intercalated with 2 to 10 m sequences of shale and thin sandstones or laminated thin limestone beds intercalated with black shales, thin bioclastic limestones composed of crinoidal debris and 10 cm beds of calcareous siltstone and sandstone. Rare beds of sandstone which contain limestone intraclasts at the base, and grade up into thin planar stratification also occur in the thin bedded sequences. The unit resembles parts of the Cow Head Group. The presence of oolitic grainstones may suggest a Cambrian age since oolitic carbonates of platformal origin in western Newfoundland mostly occur in the rocks of Cambrian age.

The second sedimentary package of unknown affinity was mapped only in the southeastern part of the Portland Creek map sheet, north of Parsons Pond. It consists of a tightly folded sequence of black, gray, khaki and green colored shales. Interbedded with the shales are nodular, laminated and massive, thinly bedded fine grained, gray limestones, and beds of laminated and cross-laminated, green-gray to buff calcareous siltstones and very fine grained micaceous sandstones. Sedimentary rocks exposed in rare outcrops within the large bogs and along some streams north of the centre of Parsons Pond include bedded gray and red cherts, green and red siltstones and mudstones as well as laminated, very fine grained sandstones. These fine grained sedimentary rocks which appear to structurally overlie unit Cgl are probably part of the Humber Arm Allochthon.

STRUCTURE

The map area like those to the north (Knight and Boyce, 1984), is dominated by a system of long, branching and anastomosing, curvilinear, high angle, north to northeast trending faults. These faults displace units vertically up to hundreds of metres and some are known to have strike-slip motion. Minor open to tight folds that parallel and trend oblique to faults have variable plunges. Locally steepened bedding and intense fracturing also characterize the fault zones.

On the Bellburns map area, particularly near and west of Eastern Blue Pond, a number of east-west faults that are generally downthrown to the northeast, cross-cut the stratigraphy and the northeast faults. In some instances, the latter offset, or terminate, against the west trending faults. An attractive structural interpretation of the area at the north end of Bateau Barrens, which is an alternative to that shown in figure 1, involves downthrowing north dipping Table Head rocks on the north side of west trending faults, against west dipping St. George Group.

Close to the Long Range Precambrian inlier near Western Blue Pond, bedding steepens and overturns in incompetent rocks such as the Forteau Formation and décollement occurs between the Forteau and the overlying Hawke Bay Formation. The Long Range western boundary fault has a sinuous to arcuate northeast trend from Parsons Pond north to Blue Mountain where the fault swings off almost eastward into the Precambrian inlier. This plus the presence of foliation and fracturing in chloritized granite and adjacent platformal rocks within a metre of the sharp fault plane suggests the fault is a thrust dipping at between 45 and 50° to the east. This conclusion is strengthened as the fault is traced south through the Indian Lookout and Portland Creek map sheets where intensity of deformation increases. Here inverted bedding, recumbent folds, eastward dipping reverse and thrust faults associated locally with recumbent west facing minor folds occur in autochthonous rocks in a zone up to 3 km wide within the adjacent platform. Older rock units override younger units westward in this zone. Caution is required in mapping the carbonates of this area, however, because most stratigraphic units have been recrystallized to a uniform fine, equigranular, vuggy, off-gray dolostone.

West of the 3 km zone of faulted platform, deformation of unnamed Middle Ordovician sandy and shaly flysch, is restricted to southeastward dipping monoclinal sequences. However, open, asymmetrical, southwest plunging folds with vertical to eastward dipping axial planes also affect the flysch along Western Feeder Brook and in Table Cove. A single cleavage occurs in interbedded shale beds.

Limestone conglomerates and thin bedded shales and limestones of unknown age structurally overlie the sandstones in a moderately dipping (12-29°) monoclinal southeastward filled sequence. However, allochthonous(?) fine siliciclastic rocks (Unit Cgl) in the southeast of the map area north of Parsons Pond are complexly deformed into a multitude of isoclinal to slightly recumbent folds that trend about 165°, and plunge gently (5 to 8°) to steeply (up to 75°) to the south. The folds which have a metre to decametre spacing, face westward with a well developed eastward dipping axial planar cleavage. Only one phase of deformation appears to have affected these rocks.

ECONOMIC GEOLOGY

The map area contains carbonate hosted Mississippi Valley-type sphalerite-rich district centred northeast of Daniels Harbour. The Daniels Harbour zinc mine, opened in 1975, recovers ore from several narrow, ribbon-like sphalerite lenses that occur in secondary dolostones that replace Catoche limestones. The mineralization occurs adjacent to collapse breccia bodies associated with a regional late Arenigian disconformity near the top of the St. George Group. Description of host rocks and mineralization is given by Collins and Smith (1975), Lane (1984) and Crossley and Lane (1984). Sphalerite mineralization is also known in the area northeast and east of the mine and includes showings and prospects, such as the Trapper, in rocks of similar type and stratigraphic position.

Outside the district, mineralization is sparse. Some sphalerite crystals have been found in dolomite-cemented vugs along the shore near Deer Cove; black diagenetic dolomites of the Watts Bight Formation from a ridge 5 km west of Flat Pond responded to the application of a zinc reactive solution. However, no visible mineralization was seen.

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METALLOGENY OF THE TALLY POND VOLCANICS, VICTORIA LAKE GROUP, CENTRAL NEWFOUNDLAND

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ABSTRACT

The Victoria Lake Group in central Newfoundland is a thick sequence of volcanic, volcaniclastic and sedimentary rocks deposited during the development of an Early-Middle Ordovician island arc. Volcanic rocks occur within two principal volcanic units, informally termed the Tulks Hill and Tally Pond volcanics. The volcanic rocks consist of intercalated mafic and felsic rocks that are predominantly pyroclastic; mafic pillow lava is more common in the Tally Pond volcanics than in the Tulks Hill volcanics. The felsic volcanics occur as laterally extensive sheets of crystal and crystal-lithic tuff, breccia and minor flows. Sedimentary rocks consist of sandstone, siltstone, shale, argillite, chert and minor interbedded conglomerate. The clastic sedimentary rocks appear to be derived from the adjacent and underlying volcanic rocks of the Victoria Lake Group to the southwest.

Six volcanogenic sulfide occurrences are known in the Victoria Lake Group. Four occur in the Tulks Hill volcanics and two in the Tally Pond volcanics. The Tally Pond (Boundary) deposit and Burnt Pond project both occur in the felsic pyroclastics of the Tally Pond volcanics. The Tally Pond deposit comprises two zones of massive sulfides underlain by a zone of pervasive chlorite-pyrite (-chalcopyrite) alteration.

INTRODUCTION

Metallogenic studies, as part of a new five-year (1984-89) project designed to investigate the pre-Caradocian volcanogenic mineral deposits of central Newfoundland, were started in July, 1984. The 1984 studies concentrated on the Tally Pond Volcanics, and involved regional rock geochemistry and detailed stratigraphic, structural and geochemical studies in the area of the Tally Pond deposit.

Access to the area is provided by woods roads from Millertown and Grand Falls. The area is characterized by a heavily forested (fir, spruce), gently undulating landscape with extensive glacial till cover. Consequently, bedrock exposure is poor.

PREVIOUS WORK

Parts of the area have been mapped in detail by mineral exploration companies, including ASARCO, Abitibi-Price and Noranda. The first systematic geological mapping was done at 1:250,000 scale by the Geological Survey of Canada (Riley, 1957; Williams, 1970). The Newfoundland Department of Mines and Energy has done 1:50,000 scale regional mapping of the King George IV Lake (12A/4), Victoria Lake (12A/6), Star Lake (12A/11E), Lake Ambrose (12A/16), Noel Paul's Brook (12A/9), Buchans (12A/15), Badger (12A/16) and Grand Falls (2D/13) map areas (Kean, 1977, 1979a,b, 1983; Kean and Jayasinghe, 1980, 1982; Kean and Mercer, 1981).

Brown (1952) proposed the name 'Victoria River Series' for the volcanic and sedimentary rocks in the Lake Ambrose - Victoria River area. Riley (1957) proposed the name 'Strides Group' for similar rocks in the western half of the Red Indian Lake map area. Kean (1977) abandoned these names and proposed and defined the 'Victoria Lake Group' to include all the pre-Caradocian volcanic and sedimentary rocks in this area (Figure 1).

Volcanogenic sulfide mineralization in the rocks presently assigned to the Victoria Lake Group was first discovered in the early 1900's near the mouth of Victoria River. Subsequently, five other volcanogenic base metal deposits have been discovered, the Jacks Pond, Tulks East, Tulks Hill and Tally Pond (Boundary) deposits and the Burnt Pond prospect.

REGIONAL GEOLOGY

The Victoria Lake Group underlies that part of the Dunnage Zone of central Newfoundland which extends from Grand Falls in the northeast to King George IV Lake in the southwest; and from Red Indian Lake in the north to Noel Paul's Brook in the south.

The Ordovician geological development of the Dunnage Zone is recorded in three very broad geologic settings: (1) ophiolitic sequences which are interpreted to have formed as oceanic crust; where contacts are preserved, these are always the stratigraphically lowest units and they are believed to represent basement to most of

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

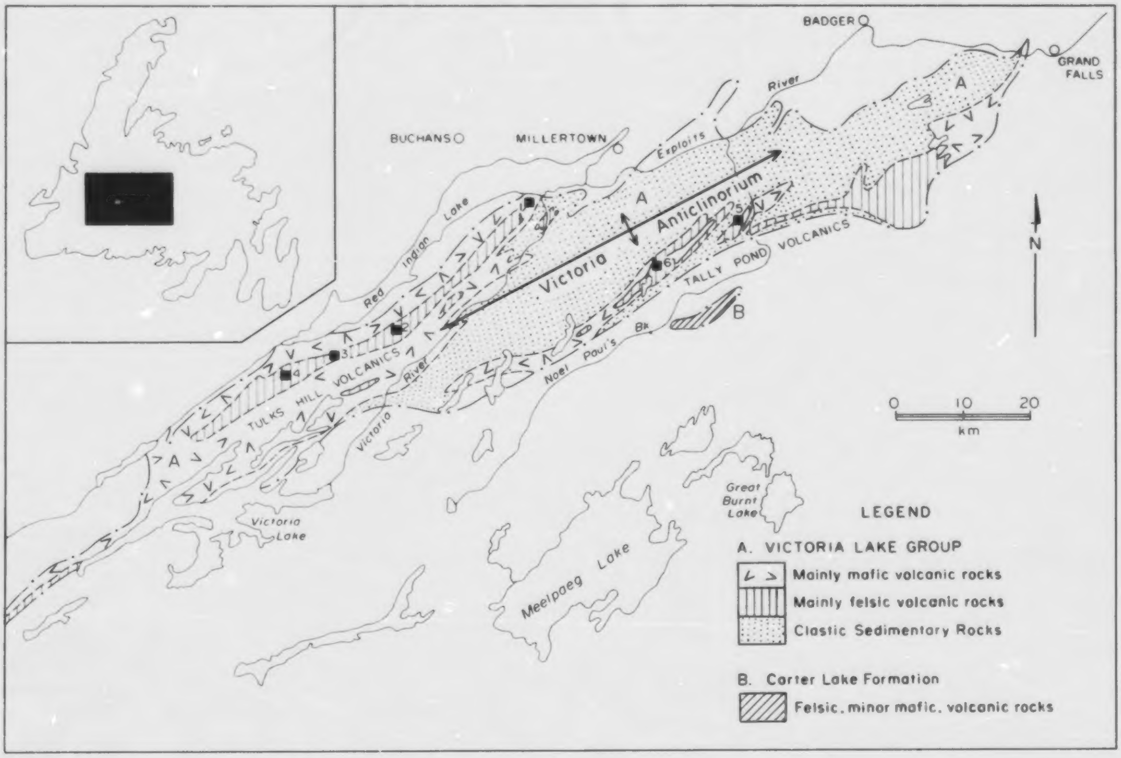

Figure 1: *Early to Middle Ordovician volcanic-dominated island arc sequences and massive sulfide deposits (solid squares) in central Newfoundland. A - Victoria Lake Group; B - Carter Lake Formation. Lines - felsic volcanic rocks; Vees - mafic and intermediate volcanic rocks; stippled - sedimentary rocks. Massive sulfide deposits: 1. Victoria Mine; 2. Jacks Pond; 3. Tulks East; 4. Tulks Hill; 5. Burnt Pond; 6. Tally Pond (after Swinden and Thorpe, in press).*

the younger rocks in the Dunnage Zone; (2) tholeiitic and calc-alkaline volcanic and subvolcanic rocks and related volcaniclastic rocks which stratigraphically overlie the ophiolites and range up to 8 km in total thickness. These units consist of mafic and felsic, dominantly submarine volcanic and volcaniclastic rocks, and are generally interpreted to represent the remains of one or more Early-Middle Ordovician island arcs; and (3) post-island arc flysch, argillite and conglomerate which stratigraphically overlie many of the island arc sequences and are mainly derived from them. These sedimentary rocks range in age from Middle Ordovician to Early Silurian and are succeeded by younger Silurian rocks consisting of subaerial, mainly felsic, volcanic rocks and terrestrial sediments.

In the south-central part of the Dunnage Zone, the ophiolite sequences are represented by the King George IV Lake, Annieopsquotch, Star Lake and Shanadithit Brook Complexes. The King George IV Lake and Annieopsquotch Complexes are faulted against the Early-Middle Ordovician island arc sequences of the Victoria Lake Group to the southwest of Red Indian Lake, but are interpreted to have been in original stratigraphic continuity (Herd and Dunning, 1979).

The Victoria Lake Group is conformably overlain by Caradocian age black shales and cherts in the northeast which in turn are conformably overlain by Middle Ordovician to Early Silurian flysch, argillite and conglomerate. Siltstone and tuffaceous sandstone of the Harbour Round Formation overlie the Victoria Lake Group in the Red Indian Lake area. This assemblage of rocks is in fault contact with the Buchans Group and the Southwest Brook Complex along the Lloyds River - Red Indian Lake fault system to the northwest.

The southern and southeastern limits of the Victoria Lake Group are marked by the unconformably overlying, locally fault-modified, Rogerson Lake Conglomerate, which in turn is faulted against the mafic volcanics of the Pine Falls Formation and unnamed volcanic, sedimentary and metamorphic rocks south of Noel Paul's Brook.

Rocks of the study area occupy a regional northeast-trending anticlinorium (Victoria Anticlinorium). Regionally, the sequence youngs northwesterly on the north limb and southeasterly on the south limb of this structure; however, there are many smaller scale, first order and second order folds resulting in variable facing directions. Poor exposure, however, generally precludes deciphering the detailed structure.

GEOLOGY OF THE VICTORIA LAKE GROUP

The Victoria Lake Group is a sequence of volcanic, epiclastic and sedimentary rocks that has been dated by conodonts collected from limestone lenses near the stratigraphic top of the Group as Late Llanvirnian (Kean and Jayasinghe, 1982). It is also conformably overlain by Carodocian shale and chert (Kean and Jayasinghe, 1982). The thickness of the Group cannot be estimated with any degree of certainty because of folding and poor exposure.

The Victoria Lake Group can be divided into two major regional facies: (1) volcanic rocks in the southwest and along its southeastern margin, comprising approximately 60% of the group, and (2) a predominantly sedimentary facies to the northeast which is laterally equivalent and derived from the volcanic rocks.

Volcanic Rocks

Volcanic rocks predominate in the southwestern part of the Victoria Lake Group and along its southeastern margin. The two principal volcanic units are informally termed the Tulks Hill volcanics in the southwest and the Tally Pond volcanics in the southeast. Due to poor exposure and complicated structural relations, it is not known whether the Tally Pond volcanics are stratigraphically equivalent to the Tulks Hill volcanics. However, the types of felsic volcanic rocks and the relative proportions of felsic and mafic lithologies in the two units are similar. Small intercalations of volcanic rocks also occur within the clastic sedimentary rock facies of the Victoria Lake Group to the northeast. Similar rock units are sporadically present farther east and are assigned to the Carter Lake Formation (Kean and Jayasinghe, 1980).

Tulks Hill volcanics: The Tulks Hill volcanics, host to the Victoria mine and the Jacks Pond, Tulks East and Tulks Hill deposits, consist of mafic to felsic volcanic rocks. The mafic volcanic rocks are mainly pyroclastic, comprising mafic to intermediate aquagene tuff, reworked tuff, lapilli tuff, agglomerate and breccia. Mafic epiclastic volcanic rocks are also common. Mafic lavas are not common in this unit, but where present they exhibit small, commonly flattened, pillows with thin selvages and little interpillow material. Pillow breccias are present locally.

The felsic volcanic rocks occur as laterally extensive sheets of crystal and crystal-lithic tuff, breccias and minor porphyritic flows and shallow intrusions. The major significant mineralization occurs in the felsic volcanics.

Tally Pond volcanics: The Tally Pond volcanics consist of intercalated mafic and felsic volcanic rocks. The mafic volcanic rocks comprise vesicular and amygdaloidal, generally pillowed, flows and mafic to andesitic tuff, agglomerate and breccia. Mafic pillow lava is more common in the Tally Pond volcanics than in the Tulks Hill volcanics. The pillows are generally small and have little interpillow material; where present, the latter consists of mafic tuff (probably hyaloclastic) and minor green chert. The breccias contain mafic volcanic rock fragments that range up to 20 cm across. Some of the breccias contain pillow fragments and are interpreted to be pillow breccias.

The felsic volcanic rocks, which are host to the Tally Pond deposit and Burnt Pond prospect, consist of tuff, lapilli tuff and breccia. Flow-banded rhyolite and rhyolitic breccia are locally present and quartz-feldspar, generally black, subvolcanic porphyries are common. The lapilli tuff consists of subangular to rounded clasts of white, gray and green dacite and rhyolite, in places flow banded, in a fine grained to locally vitric, tuffaceous matrix. The breccias contain angular felsic volcanic fragments ranging from 3 to 45 cm in length in a tuffaceous matrix. Locally, gas breccias are developed and consists of flow-aligned, *in situ* brecciated clasts in an aphanitic to vitric, siliceous matrix.

Carter Lake Formation: The Carter Lake Formation consists of predominantly felsic volcanic rocks with fewer mafic volcanic rocks. It occurs intercalated with unnamed sedimentary and metasedimentary and metavolcanic rocks south of Noel Paul's Brook, and is not part of the Victoria Lake Group, but is interpreted to be age equivalent.

Mafic volcanic rocks consisting of pillow lava and pillow breccia are minor. The pillows range from 16 to 60 cm in size and contain calcite amygdules near their margins.

Quartz and quartz-feldspar porphyries and crystal tuffs, minor crystal-lithic, fine-grained silicic tuff and faintly flow-banded rhyolite comprise the felsic volcanic rocks.

Sedimentary Rocks

Clastic sedimentary rocks constitute most of the northeastern facies of the Victoria Lake Group (Kean and Jayasinghe, 1982). This facies consists of sandstone (graywacke) with interbedded siltstone, shale, argillite, conglomerate and rare limestone. Siliceous siltstone and chert are more common near the top of the sequence. Locally, there are thin intercalations of volcanic rocks.

The sequence generally displays cyclic bedding. A typical cycle consists of a lower unit of conglomerate and pebbly sandstone constituting almost 40% of the cycle. It generally has erosional bases with scour and fill structures, load casts and flame structures. It grades upwards into sandstone, which forms about 50% of the cycle. The sandstone grades from coarse at the bottom to fine towards the top, where faint laminations, crosslaminations or convolute laminations may be developed. The sandstone layer is overlain by thinly laminated siltstone, argillite or shale. The contact between the siltstone and underlying sandstone is sharp and free of erosional features. The cycles mainly include ABCE and ABE Bouma divisions (Bouma, 1962) and, locally, CE divisions.

These clastic sedimentary rocks contain a predominance of volcanic detritus and both the amount of pyroclastic material and the coarseness of pyroclastic and epiclastic material increase towards the volcanic rocks of the Victoria Lake Group to the southwest. This suggests that the clastic sedimentary rocks were derived from the adjacent and underlying volcanic rocks of the Victoria Lake Group.

Intrusive Rocks

The Victoria Lake Group is intruded by linear bodies of medium grained quartz monzonite, minor granite and granodiorite which appear to be related to volcanism. Fine to medium grained diorite and gabbro with rare coarse grained phases occur as small plugs to large bodies throughout the Victoria Lake Group.

VOLCANOGENIC SULFIDES

Six principal volcanogenic base metal sulfide occurrences are known in the Victoria Lake Group. They are the Victoria mine and the Jacks Pond, Tulks East and Tulks Hill deposits in the Tulks Hill volcanics and the Tally Pond (Boundary) deposit and Burnt Pond prospect in the Tally Pond volcanics. The locations of these deposits and prospects are shown on Figure 1. Of these, only the Tally Pond deposit will be discussed here.

Tally Pond (Boundary) deposit: The Tally Pond (Boundary) deposit, a significant Cu-Zn-Ag massive sulfide deposit, was discovered by Noranda Exploration Limited in 1982. Grades and tonnage figures are confidential at present.

The rocks near the deposit are poorly exposed and the massive sulfide body is exposed by trenching. Diamond drill core offers the best opportunity to study the mineralization.

The deposit occurs within a gently dipping sequence of felsic lapilli tuff on the south limb of a northeast-trending anticline developed on the south limb of the Victoria Anticlinorium. However, parasitic folds, probably on the scale of tens of metres, and possible minor cross-folds complicate the local structure. The deposit occurs in an inlier of the felsic volcanics which is overlain to the north and south by fine siliceous siltstone and interbedded sandstone.

The deposit actually consists of two zones, referred to as the North and South Zones. The North Zone dips gently northwards for the most part and the South Zone dips gently southeastward; however, dips in the eastern part of the South Zone appear to be to the north. There is no conclusive evidence that the North and South Zones are structural repeats of the same stratigraphic horizon. Both zones have areas of alteration developed beneath them. Both the alteration areas extend or dip to the north. A rhyolite dome or plug with associated breccia is present in the South Zone.

The deposit mineralogy consists of fine grained pyrite and variable amounts of chalcopyrite, covellite and sphalerite; galena is present locally as a minor constituent. The contacts of the massive sulfides with the hanging wall and the footwall are sharp, although the footwall displays a zone of pervasive alteration that is generally present below the massive sulfides, in particular in the proximal facies. Also in the proximal facies, breccia textures are locally well developed. Distal parts of the massive sulfides generally display well developed bedding and laminations and, locally, graded bedding is apparent; there is generally very little alteration in the footwall in these areas.

The alteration consists mainly of variably intense chloritization accompanied by veinlets, blebs and disseminations of pyrite and lesser chalcopyrite. The chloritization is characterized by black chlorite which occurs in and replaces the matrix of the tuffs and locally completely replaces the rock. It also occurs as veins and blebs. *In situ* gas(?) brecciation and veining by chlorite and minor graphite are locally developed. Sporadically and randomly developed in the alteration zones are white, bleached areas caused by sericitization and silicification; this type of alteration is well developed in parts of the South Zone. The alteration zones are interpreted to represent volcanogenic hydrothermal activity related to massive sulfide deposition.

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QUATERNARY MAPPING, CENTRAL VOLCANIC BELT

by

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ABSTRACT

Open file releases 12A (212), Nfld. (93) and 12A (347) have been completed covering much of the Central Volcanic Belt of Newfoundland. The remaining areas will be released shortly and a comprehensive report on all these areas will be published in 1985. Three major divergent ice-flow directions have been recognized. The earliest flow was southward (160°-190°) and was succeeded by southwestward flow (220°-250°) and northeastward flow (050°-070°). Stratigraphy is limited to several exposures in the southwestern area of Red Indian Lake which record deposition possibly relating to the southward and southwestward flow and at Buchans which may relate to the northeast and southwest flows.

INTRODUCTION

Since 1978 much of the Central Volcanic Belt of Newfoundland has been mapped at a 1:50,000 scale (Figure 1). Open File releases (12A (212), Nfld (93), 12A (347)) (Vanderveer and Sparkes, 1979, 1980; Sparkes, 1984) for most of this area have been completed and the remaining areas (12A/15, 12H/1) will be released shortly. These open files include till geochemistry, landform classification, and glacial flow feature maps.

In 1985, a comprehensive report on the Quaternary geology of these areas will be published. This report will attempt to explain the complex glacial history of the Central Volcanic Belt in terms of the erosional and depositional features of the various ice advances. This report will also include summary maps of till geochemistry, texture, and lithologic composition for approximately 2000 samples.

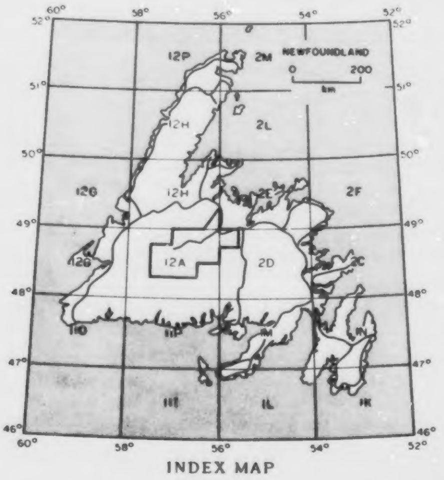

Figure 1: *Location Map: Central Volcanic Belt of Newfoundland.*

GLACIAL FLOW

Three divergent ice-flow directions have been recognized (Figure 2) (Sparkes, 1984). The earliest flow was southward (160°-190°) and appears to have affected most of the central area. It is the only flow evident in the southern part of the area. In the west (Lloyds River, Tulks River), this flow was succeeded by a southwestward flow (220°-250°), and in the central to eastern area, by a northeastward flow (050°-070°). In the Buchans area, the northeastward flow was succeeded by a southwestward flow which is probably correlative with flow in the southwestern part of the Red Indian Lake area, and may reflect the latest phase of ice movement to affect the area.

STRATIGRAPHY

Most of the study area is covered by a mantle of till of varying thickness. The till consists of rock types generally derived from local bedrock. Along the Lloyds River, Tulks River and Costigan Brook Valleys, near the southwestern end of Red Indian Lake, and along the shoreline of Victoria Lake, several important exposures provide an understanding of the glacial stratigraphy of the area (Figure 3) (Vanderveer and Sparkes, 1982).

In the Tulks River Valley, a compact, fissile, reddish brown to gray lodgement till is composed mainly of volcanic rocks of local origin (Victoria Lake Group). Minor amounts of sedimentary and intrusive clasts may be exotic (further transported), but they may also be from the related volcaniclastic rocks or small intrusive bodies within the Victoria Lake Group. Lithologically, this till is similar to the other tills in the area. The till matrix (finer than 2 mm) consists of an average of 58% sand, 33% silt and 9% clay. This differs slightly from the surface tills, which generally have lower silt and clay contents. The term 'Tulks River till' is proposed for this unit. The type section is a

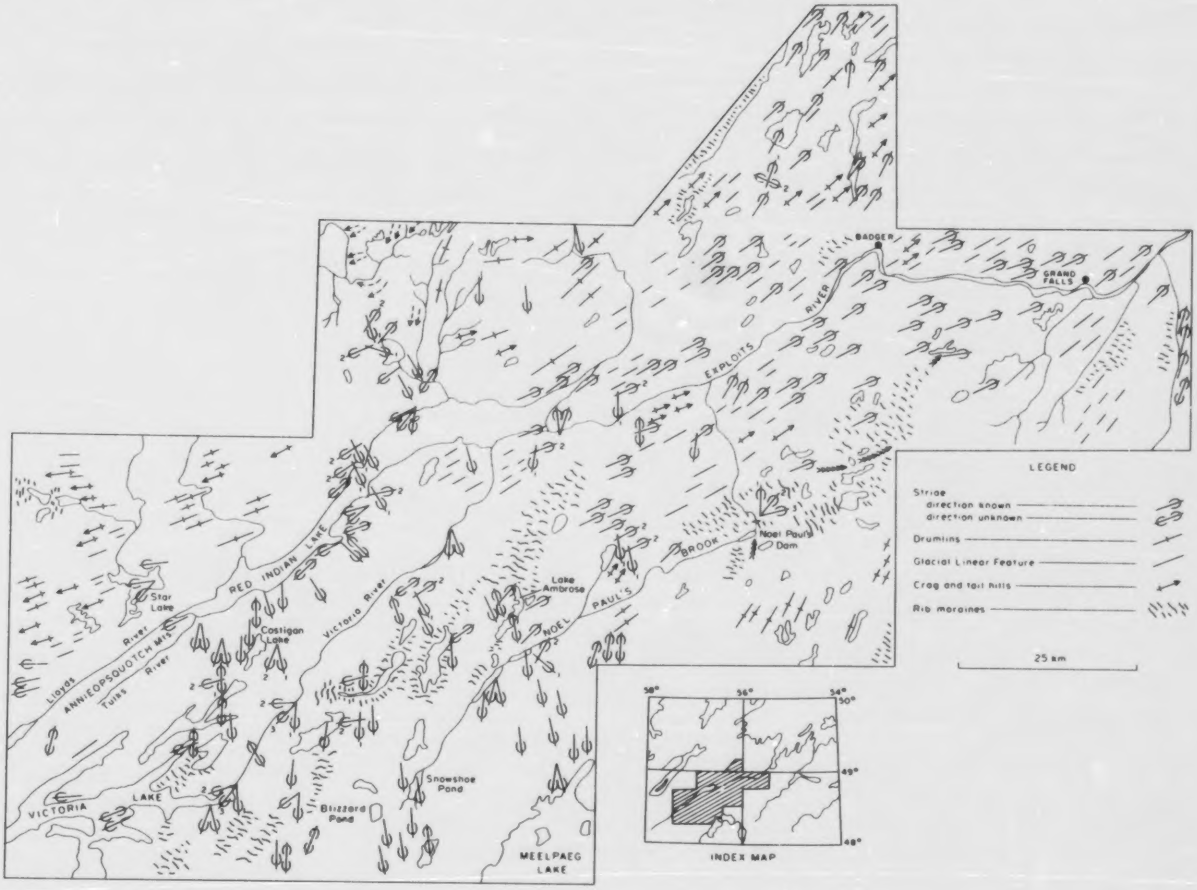

Figure 2: *Glacial flow features of the Central Volcanic Belt, Newfoundland. Numbers on striae indicate the relative age of ice flows (1 being the oldest).*

bank exposure within the river valley near Red Indian Lake (site 315). This till is overlain by a sequence of silt and clay rhythmites that is in turn overlain by a thin mantle of sandy till.

The Lloyds River Valley sections also record the deposition of rhythmites, which are here overlain by a poorly comminuted and poorly compacted sandy till of local origin. Sand and gravel outwash commonly overlie this upper till unit. The rhythmites, which often underlie till as in the Tulks River area, consist mostly of silt (67%), with lesser amounts of sand (22%) and clay (11%). They are often thinly stratified, graded and, where overlain by till, distorted or folded. The term 'Lloyds River rhythmites' is proposed for this unit. The type section is a roadcut exposure adjacent to Lloyds River (site 33).

The shoreline exposures on Victoria Lake also record a sequence of interbedded sand, gravel or sand and silt, overlain by a gray-brown compact till of local origin. The sand and silt have been disrupted and contorted, presumably during the emplacement of the upper till unit.

At Costigan Brook, near the south side of Red Indian Lake, a compact stony till containing gabbroic clasts, possibly derived from a northerly source, can probably be stratigraphically correlated with the Tulks River till. This Costigan Brook till is overlain by a thin red silty till which is overlain by sand and silt (site 301) or pebbly gravel (site 302). A thin red-brown till overlies the sand and silt at site 301.

At Buchans, in the open pit of the Oriental Mine, three distinct units are

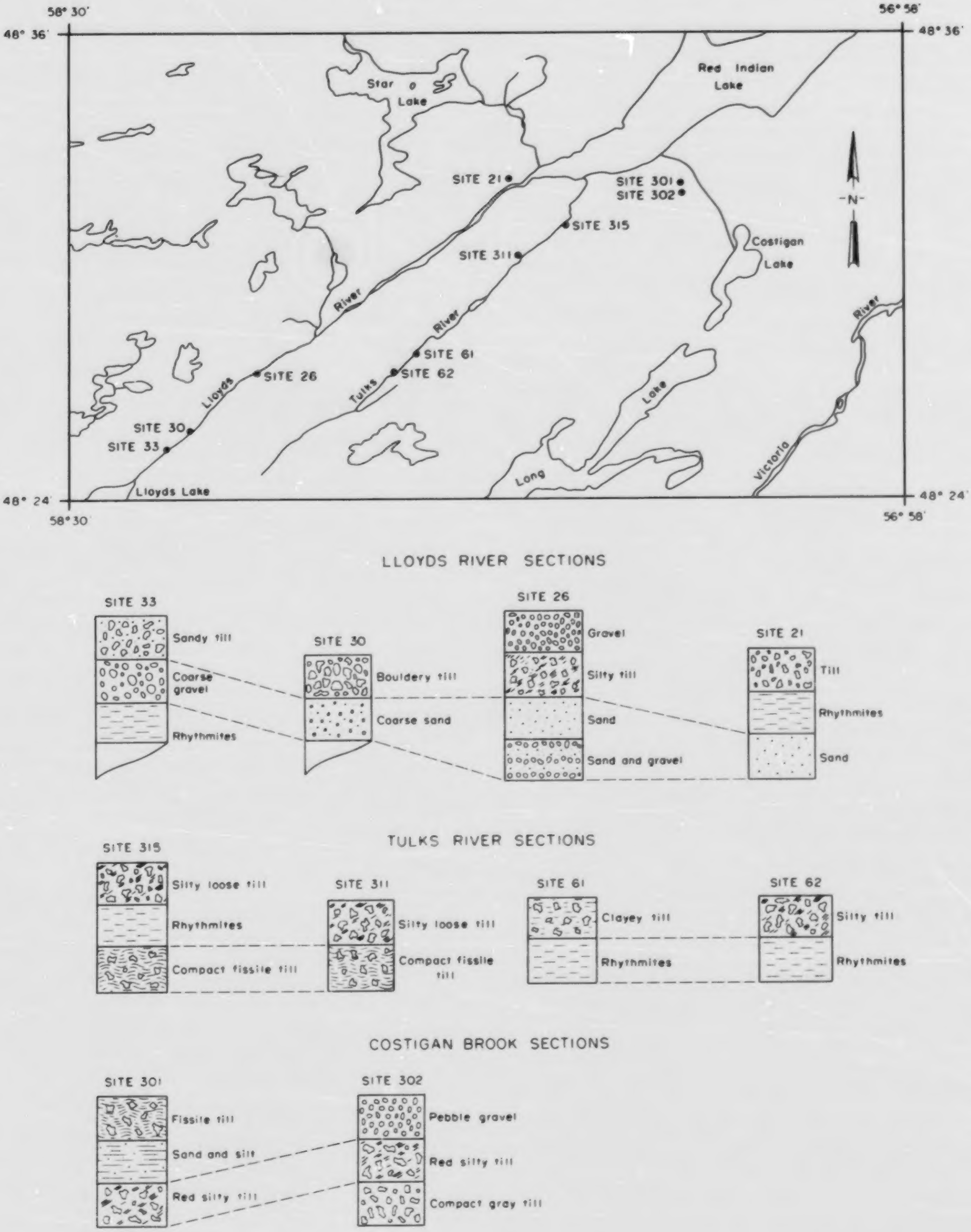

Figure 3: *Central Volcanic Belt: Stratigraphic Profiles.*

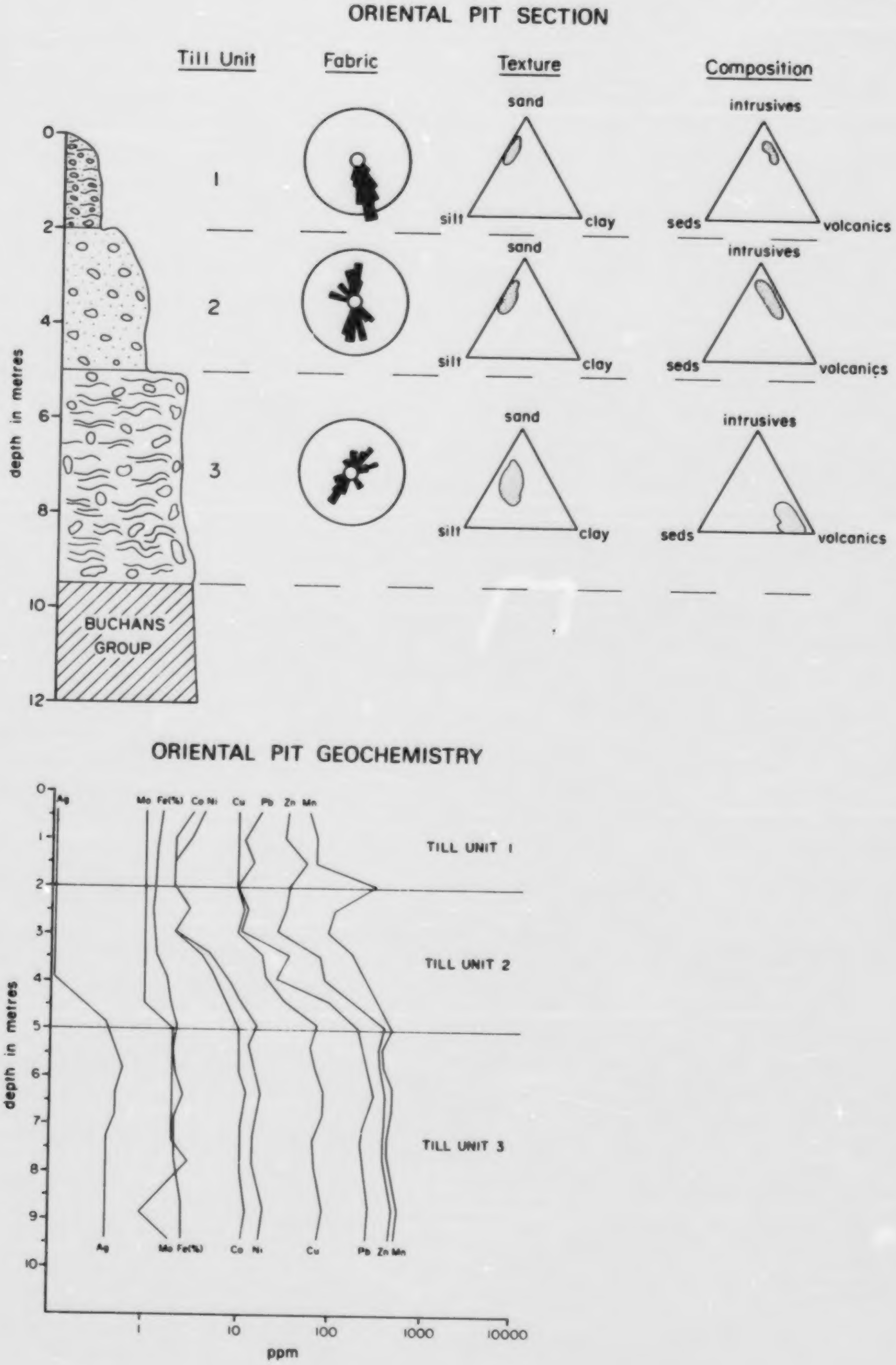

Figure 4: *Oriental Pit Section, Buchans.*

exposed (Figure 4). The upper unit (Unit 1), which exhibits some sorting, is possibly a meltout facies of Unit 2. These units are lithologically similar, consisting of mostly intrusive clasts derived from the Topsails Granite, indicating the same source (i.e., transport from the north-northeast). The characteristic red color of these tills is due to this dominant composition. The lower unit (Unit 3) is a gray, clayey, very fissile lodgement till composed mostly of volcanic clasts of the Buchans Group.

At the sandfill pit for the Asarco mining operation at Buchans, 1-2 m of moderately compact, stoney till overlies up to 50 meters of sand with minor silt bands. This till is similar to the red till in the Oriental pit and is composed of mostly granitic clasts of the Topsails Granite.

SEQUENCE OF GLACIAL EVENTS

Based upon the glacial flow indicators and stratigraphy, the following sequence of events is proposed:

(1) The early ice movement toward the south (160°-190°) radiated from a center northwest of Red Indian Lake and crossed most of the study area. This ice flow possibly deposited the Tulks River till. No age can be assigned to this event.

(2) The Lloyds River rhythmites were deposited in a proglacial lake (Vanderveer and Sparkes, 1982; Mihychuk, this volume) formed as the result of glacial damming of Red Indian Lake during the separation of the southward glacial flow into smaller local ice centers (Buchans Plateau, Lake Ambrose to Victoria Lake). The sand at the sandfill pit near Buchans, may also have been deposited at this time.

Samples of these glaciolacustrine rhythmites were analyzed for fossil pollen by J.J. McAndrews of the Royal Ontario Museum. No pollen was recorded in most of the samples but more sampling and analysis were recommended for one section which may provide more information on the depositional environment or age of the rhythmites and a minimum age for the emplacement of the Tulks River till.

(3) After deposition of the glaciolacustrine rhythmites, glaciation of the area recurred during the Late Wisconsin from at least two accumulating ice centers. Ice flow was directed northeastward and southwestward from an ice center located between Victoria Lake and Lake Ambrose (Figure 2). The northeastward flow is also evident in the area east of Buchans and may have emplaced the lower gray till exposed in the Oriental pit, although the only evidence for this is that the greatest source area for the clasts in this till lies to the west and southwest. Minor variations in the direction of these flows were probably the result of local topographic control. Subsequent to this advance, ice flowed southwestward from a center north and northeast of Buchans and occupied at least part of Red Indian Lake as well as the Lloyds River and Tulks River Valleys. This event may have deposited the red granitic till in the Oriental and sandfill pit and the till which overlies the rhythmites in these other valleys.

ACKNOWLEDGEMENTS

The author thanks Martin Batterson and Maryann Mihychuk for critically reading this report and for useful discussions regarding its content.

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DRIFT PROSPECTING IN THE VICTORIA AND TALLY POND AREAS, CENTRAL NEWFOUNDLAND

by

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ABSTRACT

Detailed studies in the Victoria area, south of Red Indian Lake, and in the Tally Pond area were conducted for the purpose of drift prospecting. Glacial deposits are thin and discontinuous in the Victoria area. Three till facies were identified; a lodgement facies related to the southerly flow; a second lodgement facies related to the northeasterly flow, and a surficial melt-out facies related to glacial retreat. A raised shoreline and associated sand deposits approximately 60 meters higher than the present level of Red Indian Lake have been interpreted as representing a glacial lake, here informally named 'Glacial Lake Shanadithit'. Results of the sampling program have not been analyzed to date.

In the Tally Pond area, glacial deposits are extensive and generally thick, averaging 5 metres. Mineralized boulders along the northwest shoreline of Tally Pond do not appear to be related to the Boundary Deposit which is in an up-ice direction. Mineralized pebbles were also located between Gill Pond and Tally Pond. These and the mineralized boulders may be related with a yet undiscovered sulphide deposit southwestwards towards Lake Ambrose.

INTRODUCTION

Two areas in the Central Volcanic Belt were selected for detailed study of the glacial geology, stratigraphy, sedimentology and geochemistry for the purpose of drift prospecting. The aim of this year's activities were to establish dispersal patterns of clasts and elements within a till sheet from known deposits, one in an area of relatively thin drift and the other in an area of thick drift cover.

The Victoria study area (12A/10) is located along the southern shore of Red Indian Lake, west of the Victoria River. The Victoria Prospect, a massive sulphide deposit, is located within the study area (Figure 1) at latitude 48°44'N and longitude 56°42'W.

The Tally Pond study area is located approximately 15 kilometres south of Millertown, at 48°35' to 48°40'N and 56°30' to 56°25'W on the 12A/10 and 12A/9 map sheets. The source of mineralized float found in the northeast corner of Tally Pond by Kean and Jayasinghe (1980) was investigated.

General Geology

The area is primarily underlain by volcanic and sedimentary rocks of the Victoria Lake group which is Middle Ordovician and older in age (Kean and Jayasinghe, 1980). A conglomerate-sandstone unit, called the Rogerson Lake Conglomerate separates the Victoria Lake Group from the mafic volcanics of the Pine Falls Formation. The area is intruded by a variety of plutons ranging from gabbro through diorite and quartz monzonite to granite. The prime mineral potential in the area appears to be related to the felsic to intermediate volcanic rocks of the Victoria Lake Group (Kean and Jayasinghe, 1980).

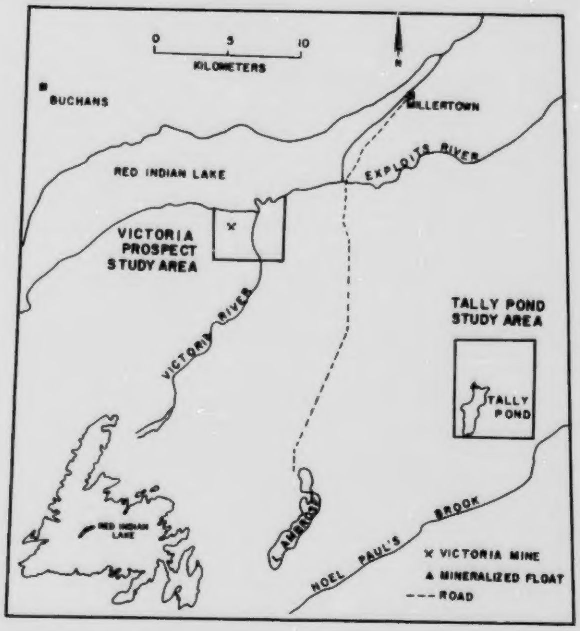

Figure 1: *Location of the Victoria and Tally Pond study areas.*

Previous Work

Early regional work on the island by Coleman (1926) recognized one ice flow direction from the west in the Millertown

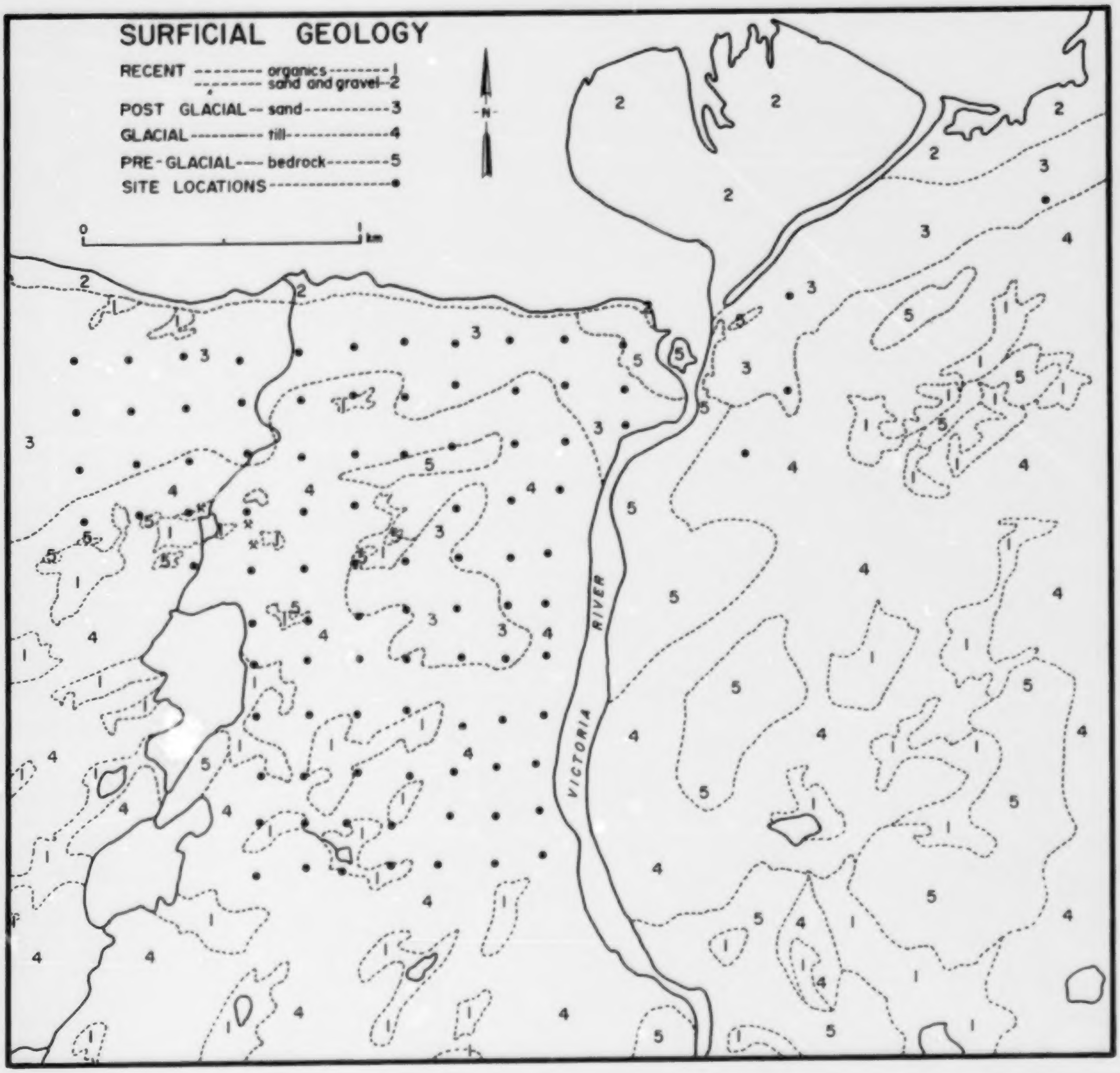
SURFICIAL GEOLOGY
RECENT -------- organics -------- 1
-------- sand and gravel -- 2
POST GLACIAL -- sand ----------- 3
GLACIAL ---------- till ------------- 4
PRE-GLACIAL ---- bedrock -------- 5
SITE LOCATIONS ----------------- ●
N
0
1 km
VICTORIA RIVER
1
2
3
4
5

Figure 2: *Surficial geology of the Victoria study area.*

area. Murray (1955) identified three ice flows in the region, with ice flowing eastwards over the Victoria study area, northeastwards in the Tally Pond area and westwards down the Lloyds Valley. The flows being related to a local ice cap over the Annieopsquotch Mountains. Murray related the southward striae in the Victoria area to local deflections, and the southward striae on the central granite area to an earlier glacial stage, where Labradorian ice extended over the island. Grant (Grant, 1974,1975,1976) suggests a model of multiple ice caps for the area, with one being centered over Red Indian Lake. He suggests growth and shifting of these local ice caps would account for the complex striae associations in the area. Vanderveer and Sparkes (1979) have proposed that the area was in undated by deflected southward flowing ice from Buchans and then by northeasterly flowing ice from an ice mass situated over the granite platform south of Noel Paul's Brook.

Methods

Grid sampling of surficial sediments at 200 meter intervals as well as more regional sampling at 500 meter intervals were conducted for the Victoria and Tally Pond study areas. Till soil profile sampling of the B, B transition C and C horizons, was done to determine geochemical trends. Pebble collections, boulder counts and bedrock samples were taken where possible. A total of 286 sites were visited and 396 samples collected. A minimum of 100 pebble clasts (16 to 32 mm) were collected for each of the 190 till sites.

Results

Victoria Area

Drift thickness varies from 0.0 to 7.0 meters. Bedrock is exposed in 10 to 15 percent of the study area (Figure 2). The primary volcanic lithologies include felsic to intermediate tuffs, lapille tuffs and localized exposures of agglomerate and mudstones. The Victoria deposit, discovered in the early 1900's and consisting of copper-zinc-lead-sulfide mineralization, is contained within north dipping and north facing felsic volcanic rocks (Thurlow, 1978; Kean and Thurlow, 1975). The grade of the ore is high but the low tonnages make the deposit presently uneconomic.

Three till units have tentatively been identified from field observations in the Victoria study area (Figure 3). The dominant surficial till facies is a grey-brown, silty-sandy unit which is moderately overconsolidated with well developed fissility. The till is generally moderately stoney; the clasts are subangular in shape and primarily volcanic. This unit has been interpreted as a lodgement facies, probably related to the latest northeasterly flow.

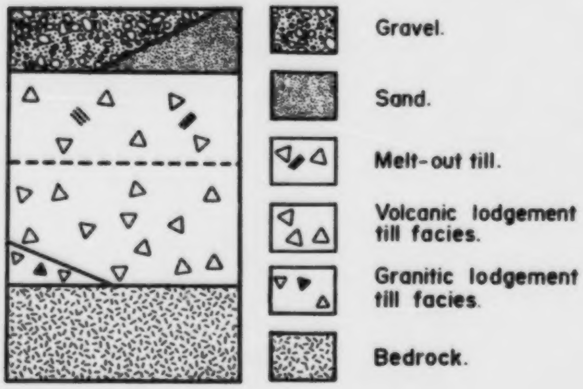
Gravel.
Sand.
Melt-out till.
Volcanic lodgement till facies.
Granitic lodgement till facies.
Bedrock.

Figure 3: *Idealized composite stratigraphy for the Victoria study area.*

At 1200 meters southwest of the Victoria River two lodgement till units were encountered. The lower till is light grey in colour with a silty matrix, contains subrounded to subangular clasts, is moderately overconsolidated, and exhibits well developed fissility. Lithologically this unit contains 48% tuff, 32% siltstone, 8% acid volcanic, 4% basic volcanics, 5% quartz pebble, 2% granite and 1% sandstone. The overlying clast-rich unit is brown-red in colour, with a sandy-silty matrix. Clasts are very angular in shape and consist of 96% tuff, 3% acid volcanics and 1% chert. This unit apparently has a very local source area, as evidenced by the lack of rounding and the pebble lithologies. The lower unit may represent the southerly earlier flow because of the presence of Topsail granites which is absent in the upper unit.

A tan-brown, sandy, stoney till unit with occasional sand lenses overlies lodgement till in several localities. It is generally underconsolidated with no apparent fissility. This unit is interpreted as a meltout till facies related to the final phases of the last ice-flow.

Medium to fine grained sand, with occasional pebbles, blanket the northern margin of the Victoria study area. These sediments were mapped to 212 meters above sea level, 60 meters above the present level of Red Indian Lake, where a well developed strandline has been identified. This evidence as well as lacustrine and deltaic sediments reported at 211 metres above sea level at the southwestern end of Red Indian Lake by Vanderveer and Sparkes (1982) are related to a proglacial lake, informally named 'Glacial Lake Shanadithit'.

Modern beach and deltaic sediments are found along the shoreline of Red Indian Lake. The sediments are generally well-rounded to very well-rounded,coarse to fine, pebble to cobble gravel.

Poor drainage over the southern two-thirds of the study area has resulted in numerous bogs and wetlands. Organic sediments vary in thickness from 0.5 to over 1.0 meters.

Ice Movements

Ice flow directions were observed at 3 locations, 1 kilometer west of the study area. At two sites, two ice flow directions could be determined from striae and miniature crag and tail features, at 155 and 075/225. At one outcrop where cross-cutting striae were observed, the southeasterly

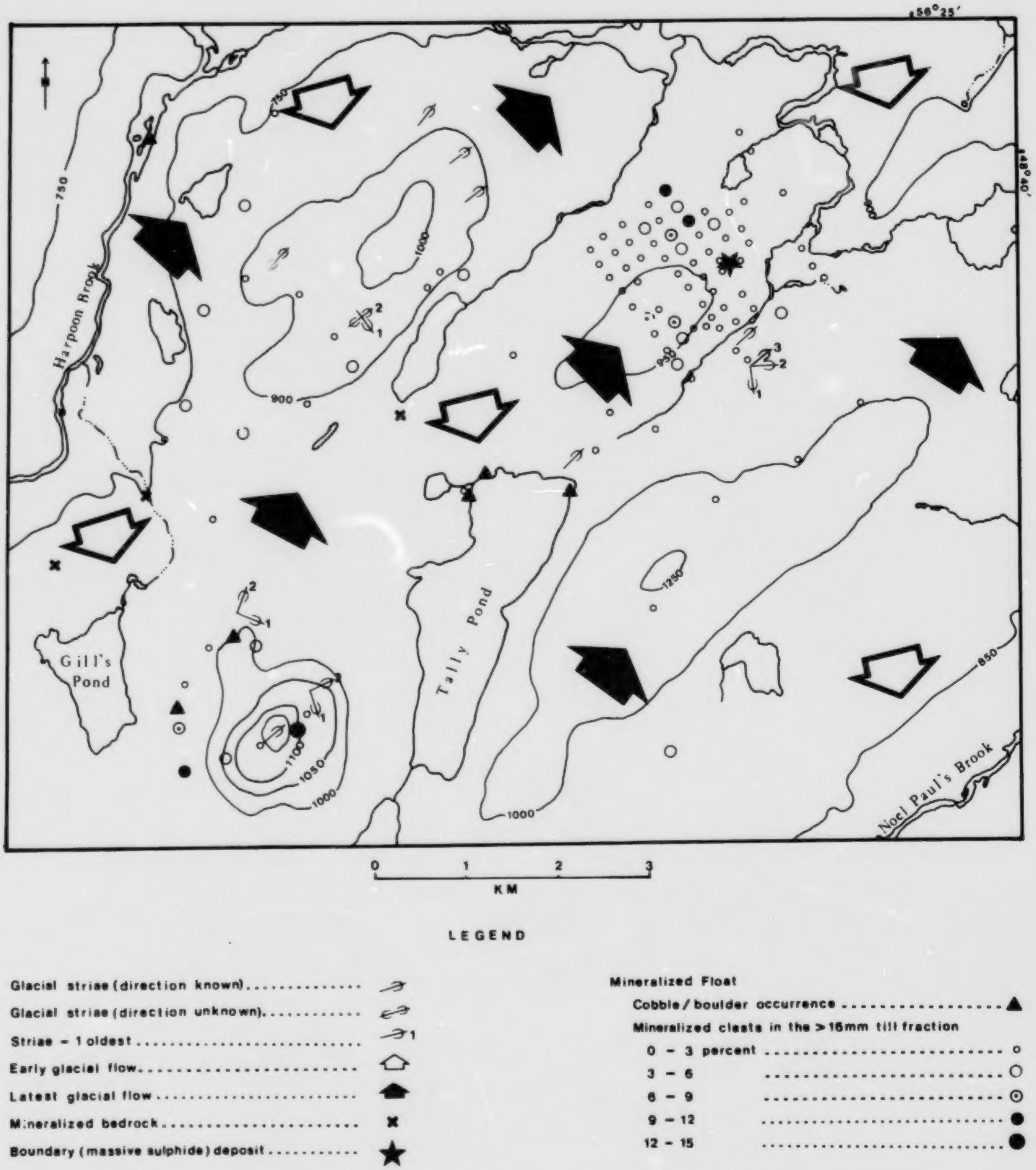

Figure 4: *Glacial ice flow features and mineralized float in the Tally Pond study area.*

direction appeared to be older. However, at the second locality, the 150 set were found on the top of the outcrop and the 075/255 set were on the ice-side protected flanks, suggesting that the 150 set is younger. The contradiction of this evidence cannot be reconciled with the limited number of exposures and the small map area.

Tally Pond Area

The Tally Pond area is in an area of moderately thick and extensive drift cover, averaging approximately 5 meters. Overburden shallows over the highlands southwest and east of Tally Pond.

Bedrock exposures are very limited, comprising less than 10.0% of the study area. The rocks in the area are part of the major band, known as the Tally Pond volcanic rocks (Jayasinghe, 1979). Major lithologies in the study area are rhyolites, brecciated rhyolites, felsic tuffs, quartz porphyry, breccias and siliceous volcanogenic sediments. From field observations in the Tally Pond area, only one till unit has been identified. The till is generally light brown, has a silty matrix, contains subrounded to subangular clasts, and is moderately to highly overconsolidated. This unit has tentatively been interpreted as a lodgement facies related to the last major ice flow to the northeast.

The dominant ice flow direction in the Tally Pond area is northeasterly at 055 (Figure 4). The crag and tail features and roche moutonnées observed indicate northeasterly flow. Only at 2 locations, a bedrock outcrop and a large boulder, which were in the same area, does striae record 3 ice flow directions. The relative ages and directions of transport were determined to be the earliest towards 180, a second to 085 and the most prominent and latest flow to 050. The significance of these 3 flows could not be determined from the very limited exposure. Glacial deposits related to the 2 earlier flows could not be found.

An area of mineralized float was located between Tally Pond and Gill's Pond (Figure 4). From the information of ice flow indicators and till stratigraphy, the mineralized float appears to have a source area to the southwest, (i.e., in an up-ice direction related to the late ice flow to the northeast). It would not appear that the area of this mineralized float is related to the Boundary Deposit which is northeast of the area.

SUMMARY

Grain size analyses and geochemistry will be conducted for the study areas and will be compiled with mapped data and released in an open file during 1985.

ACKNOWLEDGEMENTS

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GEOLOGY OF WEST PART OF GREAT BURNT LAKE (12A/8) AREA

by

S.P. Colman-Sadd

ABSTRACT

The Great Burnt Lake area is located northwest of St. Alban's in the centre of the Central Mobile Belt. This report is concerned only with the western two thirds of the area which are underlain by clastic metasedimentary rocks of presumed Ordovician age and by granitoid rocks that probably range in age from Silurian to Devonian. The metasedimentary rocks contain a prominent component of quartzite and psammite and are probably correlatives of the Spruce Brook Formation to the east. They have been penetratively deformed three times and metamorphosed in the lower to upper amphibolite facies. Mafic dikes intruded the metasediments pretectonically. The oldest of the granitoid intrusions has been very strongly deformed and has a linear outcrop area along the boundary with the Great Burnt Lake volcanic belt. Post tectonic granodiorite and minor garnet-muscovite granite are extensions of the North Bay Granite. A small body of pink biotite and/or muscovite granite is probably the youngest intrusion. The greatest potential for mineralization is in the more highly differentiated granitic rocks.

INTRODUCTION

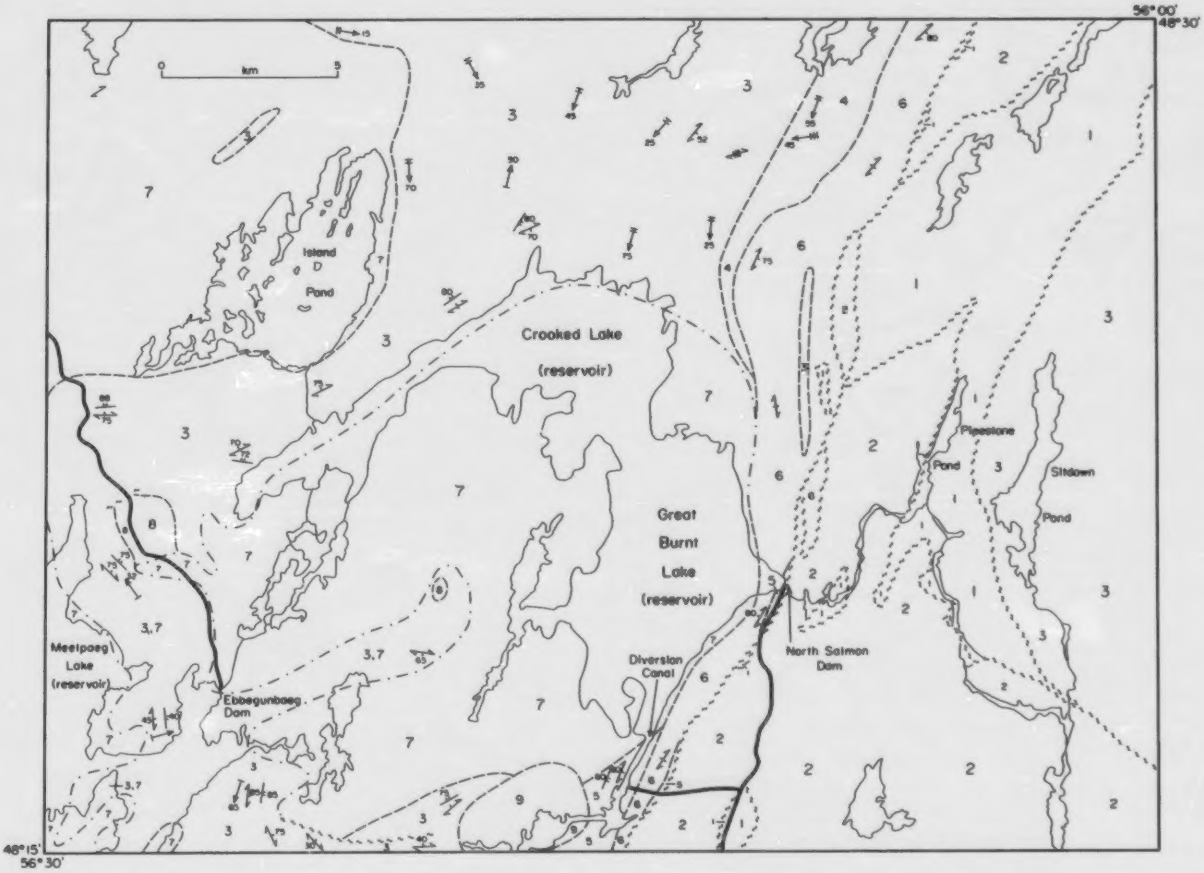
The Great Burnt Lake area is located in the center of the Newfoundland Central Mobile Belt (Williams, 1964) about 60 km northwest of St. Alban's. It is underlain in part by rocks typical of the Dunnage Zone (Williams, 1978) which form the Pipestone Pond ophiolitic complex (Unit 1) and the Great Burnt Lake volcanic belt (Unit 2) (Colman-Sadd and Swinden, 1982) in the eastern half of the area (Figure 1). To both the east and the west of these Dunnage Zone rocks are large areas of monotonous clastic metasediments (Units 3-5) intruded by granitoid rocks (Units 6-9). Where the clastic metasediments occur to the east of the Pipestone Pond Complex, they have been considered distinct from the Dunnage Zone sequences and have been named the Spruce Brook Formation. Colman-Sadd and Swinden (1984a) interpreted them to occur in a tectonic window through the Dunnage Zone. The metasedimentary rocks to the west of the Great Burnt Lake volcanic belt are essentially similar to the Spruce Brook Formation and most of them are here included in the formation.

The present report is concerned only with rocks west of the Great Burnt Lake volcanic belt, since it is these that have been mapped during 1984. The eastern part of the area was mapped at 1:20,000 in 1981 by H.S. Swinden (Swinden, 1981; Swinden and Collins, 1982) and is not discussed here. A 1:50,000 compilation map of the whole area has been published by Colman-Sadd and Swinden (1984b).

The earliest geological investigations in the Great Burnt Lake area were those of Cormack (1823) during his walk across the island of Newfoundland. Murray (Murray and Howley, 1881) visited the east shore of Great Burnt Lake on foot from Pipestone Pond, after ascending the Salmon River from Bay d'Espoir in 1870. He had intended to visit Crooked Lake and Island Pond but was prevented by the low level of the rivers. It was not until 1888 that the geological survey of Newfoundland was extended across the western part of the Great Burnt Lake area by Howley (1917), who reported that "the country around Burnt Pond (Great Burnt Lake) presents anything but an inviting prospect"; "huge angular fragments of granite are strewn in every direction" giving "the appearance of a vast ruin, which is really its true character".

No further work was done in the western part of the area until the Buchan's Mining Company set out to explore its concession in the early 1950's. Phendler (1950) and Higgins (1951) concluded that the rocks of the Pipestone Pond ophiolite and the Great Burnt Lake volcanic belt (Units 1 and 2) had by far the greatest apparent mineral potential in the area. Since then, mineral exploration, which had taken place sporadically in the ophiolite complex since 1901 (Willis, 1901), was focussed on these two units (Colman-Sadd and Swinden, 1982) and the western part of the area was explored only as a part of a 1:250,000 mapping project by the Geological Survey of Canada (Williams, 1970).

Access to the area has been much improved in recent years by the construction of roads to Ebbegunbaeg Dam in the west and North Salmon Dam in the east. Furthermore, flooding of the Meelpaeg Lake and the Great Burnt Lake - Crooked Lake reservoirs permits easy access by boat to most of the country between the two dams. During the 1984 mapping project aircraft were only needed to reach the northern edge of the area.



LEGEND

LATE SILURIAN TO DEVONIAN

9 *Equigranular pink biotite and biotite-muscovite granite.*

8 *Equigranular pink garnet-muscovite granite.*

7 *Equigranular to porphyritic, gray, biotite granite and granodiorite with unseparated migmatitic gneiss.*

6 *Very strongly deformed pink megacrystic biotite granite.*

Phases of North Bay Granite

EARLY TO MIDDLE ORDOVICIAN

5 *Semipelitic and psammitic metasedimentary rocks of uncertain affinity.*

4 *Psammite with minor quartzite and amphibolite lenses.*

3 *Spruce Brook Formation: Interbedded quartzite, psammite, semipelite and pelite; unseparated amphibolite dikes.*

2 *Great Burnt Lake volcanic belt: Unseparated metavolcanic and metasedimentary rocks.*

LATE CAMBRIAN OR EARLY ORDOVICIAN

1 *Pipestone Pond Complex: Ultramafic, mafic and felsic igneous rocks of ophiolitic affinity.*

Figure 1: *Sketch map of the Great Burnt Lake (12A/8) area. The geology of Units 1, 2 and 3 east of Great Burnt Lake is simplified after Swinden and Collins (1982).*

GENERAL GEOLOGY

The map pattern of the western part of the Great Burnt Lake area is deceptively simple, consisting of three rather similar metasedimentary units and four different types of granitoid rocks. However, the monotony of the original sedimentary units is not reflected in their complex structural and metamorphic history, which involved at least three periods of penetrative deformation and one (or more?) period of metamorphism, ranging in grade from lower amphibolite facies to the generation of a partial melt. Furthermore the contact with the Great Burnt Lake volcanic belt is marked by an abrupt change in rock types as well as by a zone of unusually intense deformation that extends for over 60 km. This contact, however it is interpreted, is a geological feature of regional significance.

Metasedimentary Rocks of Unit 3:

Most of the metasedimentary rocks in the western part of the Great Burnt Lake area are derived from essentially the same protolith as those mapped at the eastern edge of the area by Swinden and Collins (1982). The rocks at the eastern edge have been named the Spruce Brook Formation by Colman-Sadd and Swinden (1984a), and this name is probably applicable across the western part of the area and into the Cold Spring Pond (12A/1) (Colman-Sadd, 1984) and Wolf Mountain (12A/2) (Dickson and Delaney, 1984) areas.

Unit 3 consists of interbedded quartzite, psammite, semipelite and pelite. Bed thickness varies from 5 cm to 3 m and the proportions of the rock types are quite variable. Overall, quartzite and psammite each form about 20 to 30 per cent of the unit in the western part of the Great Burnt Lake area. The quartzite is light gray on fresh surfaces, but weathers white. Its grainsize is 2 mm or less and graded bedding is present in the thicker beds which have sharp, loaded bases (Plate 1). The upper parts of these beds commonly have parallel or cross laminations defined by micaceous minerals which are almost entirely absent from the massive lower parts of the beds. The psammite is darker gray than the quartzite and weathers brown. It contains more mica, but petrographic examination is required before its feldspar content can be determined. Most psammite beds are massive with sharp bed contacts and lack recognizable sedimentary structures. The pelite is medium to dark gray and, where its fine structure has not been destroyed by porphyroblast growth, is faintly laminated. Beds in which the original siltstone laminations are particularly common, have semipelitic or even psammitic compositions. The pelite and semipelite commonly contain thin interbeds of laminated and crosslaminated quartzite (Plate 2) or psammite which contrast with the thicker more massive beds described above.

Plate 1: *Quartzite bed with loaded base (under hammerhead) overlying laminated and thinly bedded sillimanite-bearing pelite, semipelite, psammite and quartzite. The quartzite bed grades towards the top of the photograph into sillimanite-bearing psammite. Spruce Brook Formation (Unit 3), near Ebbegunbaeg Dam.*

Unit 3 can be divided into two structural domains, separated by a line joining the northeastern boundaries of the two lobes of granodiorite (Unit 7), around Island Pond and Crooked Lake respectively. Southwest of this line the principal penetrative cleavage appears to have been formed during the first deformation of Unit 3 and is axial planar to tight or isoclinal folds of bedding. The cleavage is uniformly developed through the pelitic and semipelitic rocks on the mesoscopic scale, but in the psammites and particularly the quartzites it is spaced 2 to 10 mm apart and the cleavage surfaces are commonly coated with biotite and muscovite. Second deformation structures within the south-

Plate 2: *Crosslaminated quartzite bed interbedded with sillimanite-bearing pelite. Spruce Brook Formatin (Unit 3), near Ebbegunbaeg Dam.*

western domain consist mainly of open folds and a poorly developed crenulation cleavage or a further flattening of the first deformation cleavage. The second deformation structures are most prominent adjacent to the granitoid intrusions, either because of increased ductility of the metasediment due to partial melting or to deformation caused by the intrusive process.

Northeast of the Island Pond and Crooked Lake granodiorite lobes, there is an increase in both the intensity and the complexity of the structure of Unit 3. Most identifiable folds were formed during the second deformation and the first cleavage, especially the spaced cleavage in the quartzite beds, is clearly bent around the fold noses (Plate 3). In the area 5 km northeast of Island Pond, S, M and Z type folds can be used to define a major fold that is faintly visible on air photographs and has a wavelength of about 1 km. This major fold is isoclinal although the minor folds that are used for vergence determinations are mostly tight. Eastwards the minor folds also become isoclinal as the rocks become progressively more flattened. About 5 km northeast of Crooked Lake, lenses of quartzite with constant thicknesses of 5 cm to 1 m and exposed lengths of up to 20 m have either first or second deformation fold noses at their terminations, indicating that they formed by extreme flattening of Type 1 interference patterns (Ramsay, 1967). Despite the intensity of the second deformation, as indicated by the tightness of the folds, a good second deformation cleavage is not generally developed, except insofar as there is accentuated flattening of the first cleavage.

Plate 3: *Second deformation folds of the first deformation spaced cleavage in quartzite of the Spruce Brook Formation (Unit 3), north of Crooked Lake.*

Throughout most of the northeastern domain, both the first and second deformation structures trend northeast or north, except close to the Island Pond granodiorite lobe where they curve around the intrusion to the northwest. Generally the first deformation fold axes plunge fairly steeply to the northeast and the second deformation axes plunge fairly steeply to the south or southwest. Superimposed on all these structures in the easternmost part of the outcrop area, are structures of a third generation. The third deformation folds are tight to open mesoscopic structures that refold second deformation folds and have moderate plunges to the west-southwest. They are associated with a well developed crenulation cleavage that strikes west-southwest and in many places can be observed to cut obliquely across both limbs of second deformation folds.

Unit 3 is everywhere metamorphosed in the amphibolite facies and metamorphic biotite is universally present. Except in the northeastern structural domain, andalusite porphyroblasts or sillimanite aggregates are generally recognizable. It is uncertain whether the apparent absence of these minerals from the northeastern domain is due to a lower grade of metamorphism or to their destruction by the later structural events. Sillimanite appears to have a spatial relationship to the contacts with the granodiorite plutons. The inversion of andalusite to sillimanite in most cases occurs within 0.5 to 1.5 km of the contacts, although around Meelpaeg Lake where dikes and sills of granodiorite are common in the metasediments the width of the sillimanite zone is somewhat greater. Partial melting of the sediments has taken place in the arm of Unit 3 that extends east from Meelpaeg Lake towards Great Burnt Lake and adjacent to the Island Pond granodiorite lobe on the Ebbegunbaeg road. In these places the rocks have been converted to migmatitic gneisses with few relics of original bedding (Plate 4).

Plate 4: *Migmatitic gneiss probably formed by metamorphism of the Spruce Brook Formation (Unit 3) and cut by garnet-tourmaline-muscovite pegmatite veins. Road to Ebbegunbaeg Dam, west of Island Pond.*

The peak of metamorphism marked by andalusite and sillimanite growth probably took place after the first but before the second deformation. Andalusite porphyroblasts have inclusion trails of the first fabric, but they also appear to form augen in the main fabric, perhaps as a result of flattening during the last part of the first deformation or during the second deformation.

Metasedimentary Rocks of Unit 4:

Unit 4 is separated from Unit 3 because it has a much greater content of gray, brown-weathering psammitic schist and most exposures consist of homogeneous psammite with little or no evidence of the original bedding. A close relationship to Unit 3 is indicated by relics of white-weathering quartzite beds, mostly preserved in dismembered fold hinges. Unit 4 occurs as a single narrow belt at the east edge of the main outcrop area of Unit 3, but rocks of Unit 3 do occur farther east, enclosed in the foliated megacrystic granite (Unit 6) and to the east of the Pipestone Pond ophiolitic complex (Colman-Sadd and Swinden, 1984a).

The psammitic schist of Unit 4 has a pervasive, but poorly developed foliation which is tightly crenulated on a scale of about 1 cm and generally has no consistent orientation. A second cleavage, formed axial planar to the crenulations, has a steep attitude that trends north-northeast parallel to the length of the belt. The second cleavage has locally been refolded by the third generation of west-southwest plunging folds, noted in Unit 3, and these folds have a third axial planar crenulation cleavage associated with them. The most prominent metamorphic minerals in the are biotite and muscovite, defining the foliations, and garnet porphyroblasts up to 1 cm across that form augen within the second foliation, but appear to overgrow the first.

Metasedimentary Rocks of Unit 5:

Rocks of Unit 5 occur as a narrow, probably faulted, slice on the road just south of the North Salmon Dam, and on the Diversion Canal south of Great Burnt Lake. Their stratigraphic affinity is uncertain. Lithologically they most closely resemble rocks of the Salmon River Dam Formation which forms part of the Baie d'Espoir Group and is in conformable contact with rocks of the Great Burnt Lake volcanic belt (Unit 2) in the Cold Spring Pond (12A/1) area to the south (Swinden and Collins, 1982). Within the Great Burnt Lake area, however, Unit 5 is apparently separated from Unit 2 by faults (and also locally by granite of Unit 6) and has a metamorphic grade that is markedly higher than that of Unit 2, but similar to that in parts of Units 3 and 4.

Unit 5 consists of dark purplish-gray psammite interbedded with similarly coloured schist. Beds are up to 1 m thick in the psammite and 10 cm thick in the schist. Garnet porphyroblasts commonly occur as augen within the main cleavage (S_2?) in both rock types. Thin beds of laminated green or white quartzite with gradational boundaries occur in the psammite beds and these are associated with sharply bounded beds or lenses of garnetiferous calc-silicate rock. Both of these latter, accessory rock types, as well as the purplish gray colour of the psammite and schist, are characteristic of the Salmon River Dam Formation.

Mafic Intrusive Rocks (unseparated on map)

Mafic dikes clearly cross cut rocks of Unit 3 in many exposures between Island Pond and Meelpaeg Lake, and southwards into the Cold Spring Pond area. The dikes now consist of amphibolite with or without plagioclase phenocrysts and have a moderate foliation which probably corresponds to the first deformation cleavage in the country rocks. Dikes and probable relics of dikes also occur in the rocks of Units 3 and 4 east of Island Pond, but they are much less common. In the rocks northeast of Crooked Lake, that have undergone intense second deformation strain, dismembered fold hinges of amphibolite are the main evidence for the original presence of the dikes.

Strongly Deformed Megacrystic Granite (Unit 6):

Granite of Unit 6 (Plate 5) forms a narrow belt extending from north to south across the Great Burnt Lake area. In the Cold Spring Pond (12A/1) area to the south, the granite reappears south of rocks correlative with Unit 2 and continues with minor interruption to the northern edge of the North Bay Granite (Colman-Sadd, 1984). The belt has a total length of about 60 km, but at no point is it more than 7 km wide. In a general way the granite follows the boundary that separates, in the west, rocks of Units 3, 4 and 5 and their more metamorphosed equivalents in the Cold Spring Pond area from, in the east, the Great Burnt Lake volcanic belt (Unit 2).

The groundmass of the granite consists of elongated grains or grain aggregates of quartz and feldspar, and strongly oriented biotite. Muscovite occurs as an accessory mica probably of secondary origin. Potassium feldspar forms megacrysts up to 2 cm across which are subhedral or anhedral and are enclosed in the foliation as augen. The fabric is either linear with a moderate planar component or entirely linear. The planar component is generally nearly vertical and the linear component is nearly horizontal. The fabric is parallel to the overall trend of the granite outcrop which varies from northeast to just west of north. The granite contains xenoliths of psammitic schist and amphibolite which are oriented parallel to the fabric, and is cut by aplite dikes that have been deformed with the granite but which remain slightly oblique to the fabric.

Plate 5: *Megacrystic granite of Unit 6 with a strong L-S fabric, northeast of Crooked Lake.*

No contacts have been observed between the megacrystic granite and the other units. It is presumed to be in fault contact with Units 1 and 2 because of the abrupt truncation of many divisions within these units (Swinden and Collins, 1982) and because of the absence of these units farther to the west. Also the presence of several deformed ophiolite pods (Unit 1) along the line of the contact suggests that it is tectonic. The contacts with Units 3, 4 and 5 may be faulted or intrusive. The intense deformation of the more easterly parts of Units 3 and 4 is a feature that they have in common with the granite, suggesting that their contact is pretectonic and may well be intrusive; this would be consistent with relationships observed in the Cold Spring Pond area (Colman-Sadd, 1984).

North Bay Granite (Units 7 and 8):

The northern part of the North Bay Granite (Jewell, 1939; Dickson and Delaney, 1984) extends into the Great Burnt Lake area as two lobes around Island Pond and the Crooked Lake - Great Burnt Lake reservoir respectively. The latter lobe is separated from the main part of the intrusion by a zone (Units 3 and 7) of mixed metasediment (75 percent) and granite/granodiorite (25 percent) northwest of Ebbegunbaeg Dam.

Unit 7, which forms the greater part of the intrusion in the map area, consists of gray, medium grained, biotite granodiorite. Although in a few places the granodiorite is equigranular, generally it contains prismatic phenocrysts of potassium feldspar, 1 to 4 cm long (Plate 6). The granodiorite passes, over a fairly sharp transition zone along the Ebbegunbaeg Dam road, into pink, medium-fine grained, muscovite-garnet granite (Unit 8). Farther to the north, and south of the Island Pond lobe, the metasediments of Unit 3 are cut by numerous veins of pegmatite and aplite containing muscovite, garnet, tourmaline and beryl (Plate 4). Similar pegmatites also occur northeast of Island Pond, and another small intrusion of Unit 8 is suspected west of Great Burnt Lake on the basis of boulder distributions. Rocks of Units and 8 are, for the most part, undeformed, but in a few exposures, especially northwest of Island Pond, there is a very slight fabric defined by alignment of mica and elongation of quartz grains. In some exposures just west of Great Burnt Lake a gneissic foliation has resulted from the partial assimilation of metasedimentary xenoliths (Plate 7), and is not the result of post intrusion deformation.

Plate 6: *Porphyritic granodiorite (Unit 7) of the North Bay Granite, east shore of Great Burnt Lake.*

Plate 7: *Partially assimilated xenoliths of metasedimentary rock in granodiorite of Unit 7, just west of Great Burnt Lake.*

Both Units 7 and 8 have exposed intrusive contacts with Unit 3. The relationships to Units 4, 5 and 6 have not been observed, but are assumed to be intrusive and post-tectonic.

Pink Equigranular Granite (Unit 9):

Unit 9 has been observed in only two exposures in each of the Great Burnt Lake and Cold Spring Pond areas (Colman-Sadd and Swinden, 1983). It consists, in all of these localities, of unfoliated, equigranular, medium grained, pink biotite granite. The presence of a muscovite bearing phase is suspected from the occurrence of boulders of pink biotite-muscovite granite close to the exposures of biotite granite. The granite is assumed to be intrusive into Units 3, 5 and 7, although in the case of Unit 7 there is no structural evidence on which to base a time relationship.

MINERAL POTENTIAL

Higgins (1951) indicated that the main potential for economic mineralization in the Great Burnt Lake area resides in the ophiolitic and volcanic rocks of the Pipestone Pond complex (Unit 1) and the Great Burnt Lake volcanic belt (Unit 2). His recommendations have apparently turned out to be correct, although they may have been to some degree self-fulfilling, since they have caused exploration companies to ignore all units other than 1 and 2.

The present work has confirmed Higgins' opinion of most of the units in the western part of the area, but has also identified two exceptions. The highly differentiated granites of Units 8 and 9 present a prospecting environment that has only become popular in the northern Appalachians since the mid 1970's. Unit 8, in particular, appears to have formed from a silica rich fraction of the main North Bay Granite and occurs in close proximity to garnet-tourmaline-beryl pegmatites. The association is similar to that found 50 km away, near Granite Lake, where extensive tungsten mineralization is known to occur in highly differentiated parts of the same batholith (Dickson, 1982).

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Anthony Benoit is thanked for his usual cheerful and indispensable assistance in the field.

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GEOLOGY OF THE BURGEO MAP AREA (11P/12), SOUTHWESTERN NEWFOUNDLAND

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ABSTRACT

The Burgeo map area lies within the southwestern segment of the Hermitage Flexure of the Newfoundland Appalachians. The area is underlain primarily by granitoid rocks of the synkinematic Burgeo granite and the late to posttectonic Chetwynd granite. Both plutons contain zones of earlier migmatite whose protoliths include sedimentary rocks of the mid-Ordovician Bay du Nord Group and gabbros of equivocal age and origin. The Burgeo granite is an extensive early to mid-Silurian, synkinematic, composite, granitoid pluton. Its earliest intrusive phases are diorite and xenolith-rich K-feldspar porphyritic granodiorite; subsequent phases are more granitic in composition. Field relationships indicate that magmatism produced distinct, albeit temporally overlapping, phases. The Chetwynd granite is a high level, siliceous granitoid that intruded the Burgeo granite after the culmination of the regional tectonothermal event. It has untested potential for economic concentrations of F-Sn-W-Mo and U.

INTRODUCTION

The Burgeo map area (Figure 1), bounded by north latitudes 47°30' and 47°45' and west longitudes 57°30' and 58°00', is centred approximately 8 km west of Burgeo, on the southwest coast of Newfoundland. Most of the Burgeo map area east of Grandy's Brook is accessible via route 480, a partially paved highway, which bisects the map area. The area west of Grandy's Brook is in part accessible from the coast; ready access to the remainder requires aircraft support.

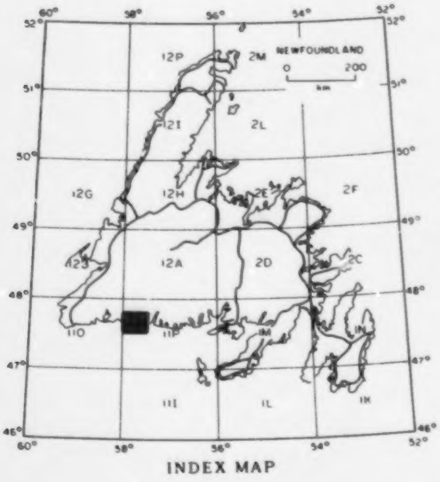


Figure 1: *Location of the study area.*

Physiographically, the area forms part of the "Atlantic Uplands" of Twenhofel and McClintock (1940), and is characterized by a dissected peneplain surface marked by monadnocks at approximately 330 m to 350 m. Evidence of the Wisconsin glaciation is found in the wide variety of depositional and erosional glacial landforms and features. Geological control of topography is evident in the topographic contrast between areas underlain by the Burgeo and Chetwynd granites. Much of the area underlain by porphyritic phases of the Burgeo granite has an irregular, rugged topography, which southwards is further dissected by fault controlled valleys and gorges. In contrast the mainly equigranular Chetwynd granite and the lithologically similar parts of the Burgeo granite are characterized by a gentle, more rolling topography.

Previous systematic geological studies in the Burgeo area include the 1:250,000 scale mapping of Riley (1959); regional reconnaissance mapping was carried out by the Buchans Mining Company (Scott and Conn, 1950) and a 1:50,000 scale compilation of this work was published by Smyth (1979). Regional lake sediment geochemical studies by the Newfoundland Department of Mines and Energy (Butler and Davenport, 1980) led to follow-up exploration by Shell Canada Resources Ltd. and Falconbridge Nickel Co. Ltd. (Barry et al., 1981). Airborne gamma-ray spectrometric surveys of the region were carried out by the Geological Survey of Canada in 1984.

GENERAL GEOLOGY

The Burgeo map area is underlain by granite and migmatite, part of the Hermitage Flexure (Williams et al., 1970) of the southern Newfoundland Appalachians. The area contains three major geological elements:

1. An Ordovician or earlier suite of metasediment, paragneiss and migmatite,

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

2. The Burgeo granite, a large Silurian (?), mostly synkinematic, lithologically diverse pluton of mainly granodioritic to granitic composition, and

3. The Chetwynd granite, a Devonian (?), essentially posttectonic, high level, quartz rich pluton.

MIGMATITES AND METASEDIMENTARY ROCKS (Units 1 and 2)

These rocks include the migmatites, agmatites, metasedimentary rocks and paragneisses that are intruded by and form xenoliths within the Burgeo granite and, to a lesser degree, within the Chetwynd granite. Unit 1 consists mainly of migmatite and agmatite with amphibolite and minor paragneiss. Unit 2 is generally of metasedimentary origin but contains minor amphibolite.

Unit 1

Migmatite and agmatite of Unit 1 are exposed mainly along a 2 km wide coastal strip west of Burgeo, underlying much of the Sandbanks and the eastern part of the Big Barasway (Figure 2). A diagnostic feature of Unit 1 migmatite is that it forms well rounded, albeit knobby, gray weathering exposures that are largely devoid of any vegetation. Rocks of Unit 1 display a random gradation between agmatite and migmatite. The agmatites consist of dark green and gray to black, either massive or banded gabbro and diorite xenoliths in a granitoid host (Plate 1). The The orientation of banding within the blocks varies widely from that which is developed in the surrounding granitoid. The granitoid is mainly equigranular but locally contains rare feldspar phenocrysts, and has a weakly developed to pronounced banding. The blocks are either flattened or subrounded to rounded and rarely angular; they range from a few centimetres to approximately 2 m in maximum dimension (Plate 2). Within the agmatite, the proportion of matrix to inclusion is highly variable, and the inclusions show varying degrees of migmatization or assimilation into the granitoid matrix (Plates 3 and 4). The true migmatites display raft textures, together with nebulitic and schlieren structures. Commonly, these migmatites are irregularly layered into biotite ± hornblende rich bands and granitoid bands. Orientation of the banding is quite variable. The banding itself is variably developed and the migmatite leucosome may be either gneissic or nebulitic and, locally massive (Plate 5). In the nebulitic migmatite good equigranular texture is preserved; grain size is variable but usually about 1-2 mm. Very rarely, the granitoid contains isolated feldspar phenocrysts. Locally, the migmatite is cut by posttectonic coarse grained, muscovite rich, granitoid pegmatite.

Plate 1: *Gabbroic xenoliths in agmatite of Unit 1.*

Plate 2: *Large xenolith of banded gabbro, Unit 1.*

Unit 1a consists of the migmatite and agmatite which underlies an area of about 7 km^2 near the Wolf Hills, approximately 6 km north of Burgeo. The migmatite is designated as a separate subunit because it contains irregularly shaped and sized rafts and xenoliths of paragneiss, as well as amphibolite and gabbro. The migmatitic granitoid is well banded or nebulitic, and contains irregular shaped zones with a

LEGEND

PLEISTOCENE TO RECENT

12 *Unconsolidated sand and cobbles.*

DEVONIAN AND EARLIER

11 *Fine and medium grained diabase.*

10 *Pink, quartz-feldspar porphyry.*

CHETWYND GRANITE

9 *Pink, fine grained, equigranular or quartz porphyritic granite: coarse grained equigranular granite and minor K-feldspar porphyritic granite; 9a, pink equigranular granite with screens of rhyolite tuff.*

BURGEO GRANITE (Units 3 to 8)

8 *Pale pink to white, fine to locally coarse grained, equigranular biotite ± muscovite, rarely garnetiferous granite and adamellite; minor aplite; 8a, dark grey, foliated, equigranular biotite ± muscovite granite and granodiorite.*

7 *Pink, orange and red, coarse grained porphyritic adamellite and granite.*

6 *Pink, medium and coarse grained, phenocryst rich, K-feldspar porphyritic granite; 6a, aplite.*

5 *Grey and pale pink, variably porphyritic granite and adamellite; minor aplite; 5a, unseparated variably porphyritic and equigranular granite.*

4 *Grey, white and pale pink, foliated, coarse grained, K-feldspar porphyritic, xenolith bearing granodiorite; minor adamellite; 4a, xenolith rich porphyritic granodiorite; 4b, pink aplite; 4c, granite pegmatite.*

3 *Dark green and grey, fine to medium grained diorite; minor agmatite.*

ORDOVICIAN(?)

2 *Migmatized semi-pelitic schist; paragneiss; amphibolite; granite migmatite.*

1 *Migmatite, including agmatite, and associated granitoid; 1a, migmatite, biotite schist, amphibolite and metadiorite; minor peletic schist; 1b, grey migmatic to equigranular granitoid.*

Plate 3: *Partially assimilated diorite xenolith in migmatite of Unit 1.*

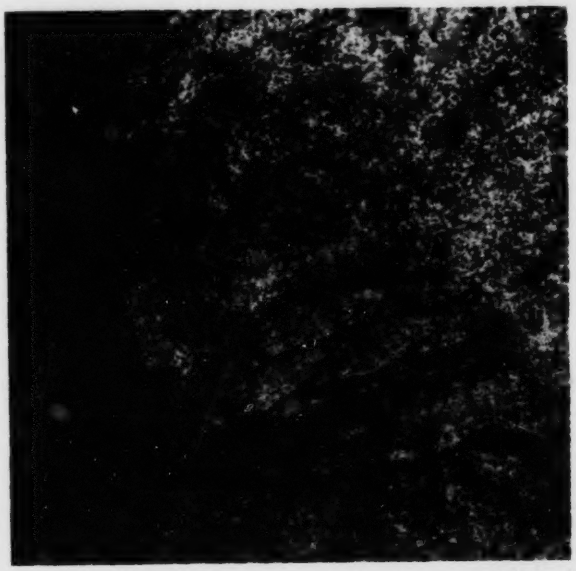
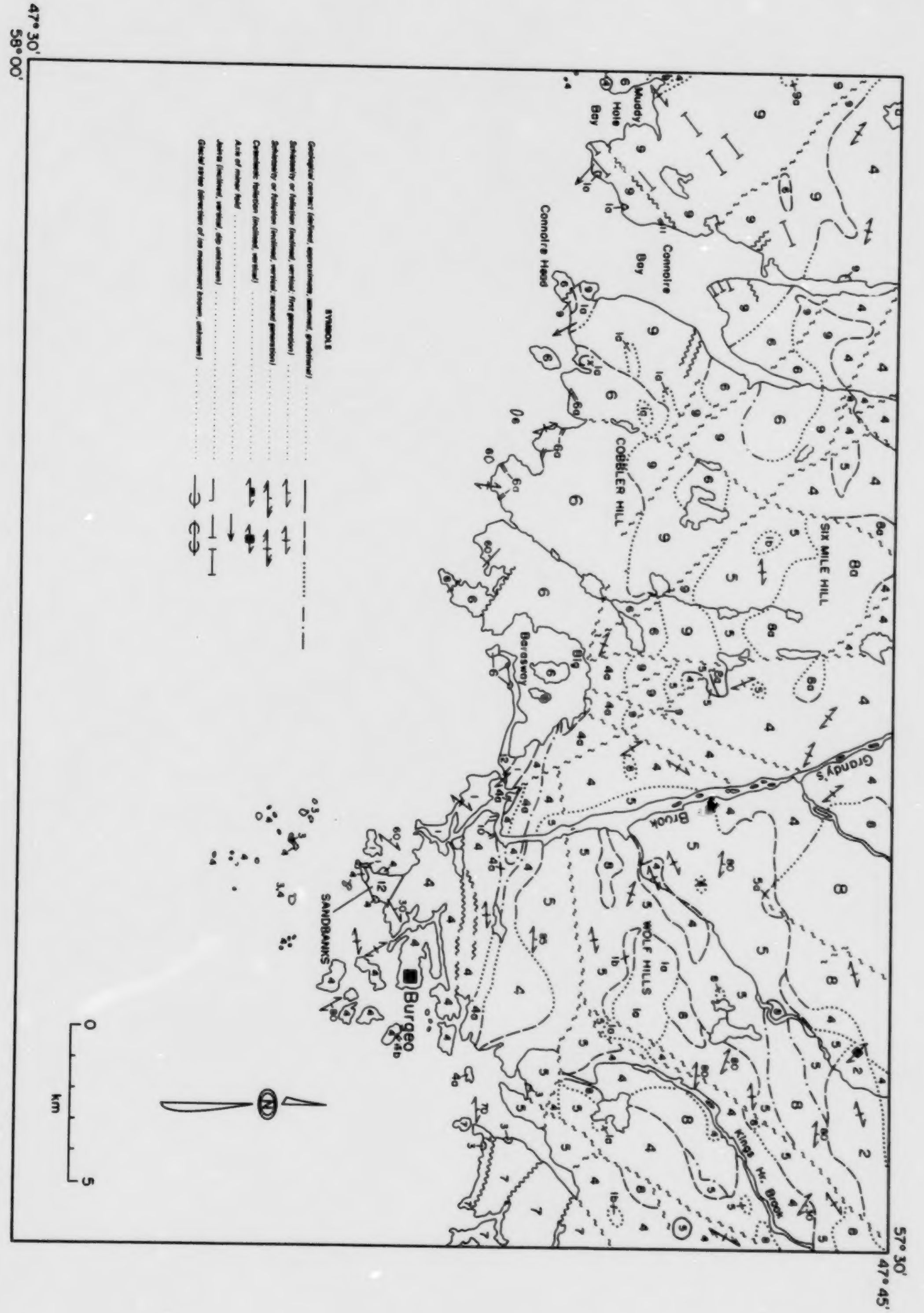


Plate 4: *Remnants of metabasic xenolith in migmatite of Unit 1.*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Connoire Head
COBBLER HILL
SIX MILE HILL
Grandy's Brook
Big Barasway
SANDBANKS
Burgeo
WOLF HILLS
Kings Hr. Brook
SYMBOLS
Geological contact (defined, approximate, assumed, gradational)
Schistosity or foliation (inclined, vertical; first generation)
Schistosity or foliation (inclined, vertical; second generation)
Cataclastic foliation (inclined, vertical)
Axis of minor fold
Joint (inclined, vertical, dip unknown)
Glacial striae (direction of ice movement known, unknown)
N
0
km
5

Figure 2: *Geology of the Burgeo Map area, southwestern Newfoundland.*

Plate 5: *Banding in leucosome of Unit 1 migmatite.*

Plate 6: *Migmatized metasedimentary raft in the Chetwynd granite.*

coarser grain size than that of the surrounding rock. As is the case with Unit 1, migmatites of Unit 1a are cut by post-tectonic muscovite-bearing granite pegmatite dikes.

Unit 1b consists of fine to medium grained, gray, mainly equigranular to nebulitic granite, which borders Unit 1a to the south. It grades northwards into Unit 1a migmatite.

Unit 2

Unit 2 is a poorly exposed zone of metasedimentary rocks, granite and migmatite that is surrounded by equigranular and porphyritic phases of the Burgeo granite in the northeasternmost corner of the Burgeo map area. Similar metasedimentary migmatite occurs as inclusions in the Chetwynd granite, east of Connoire Bay. It consists of biotite schist associated with amphibolite, variably migmatized semipelite and associated psammite (Plate 6). Associated with, but not in contact with the metasediments, is a cataclastically foliated, locally migmatitic granitoid, containing xenoliths of paragneiss and amphibolite.

The origin of Unit 2 and its relationship to Unit 1 are uncertain. The migmatites and the metasedimentary rocks are probably equivalent to either the Ordovician La Poile or Bay du Nord Groups, exposed nearby (O'Brien, 1983; O'Brien and Tomlin, 1984; Blackwood, 1984). Presumably, the paragneiss has a similar protolith.

Burgeo granite (Units 3,4,5,6,7,8)

The Burgeo granite is a new name that is informally proposed to denote the large (approximately 3,000 km^2), roughly semicircular shaped, synkinematic granitoid pluton in southwestern Newfoundland, which is exposed between Connoire Bay and La Hune and whose northernmost extension lies near Top Pond (approximately 47°56' latitude). The new name Burgeo granite replaces the previously used name Burgeo Batholith (Williams, 1978; O'Brien, 1983; O'Brien and Tomlin, 1984).

U/Pb isotopic studies on the Burgeo granite are ongoing; finalized data are not available at the time of writing, but an early to mid-Silurian age is indicated by preliminary results (Krogh, personal communication, 1984).

The Burgeo granite underlies approximately 340 km^2 in the Burgeo map area, and represents almost 75 percent of the total land area there. On the basis of texture, lithology and field relationships, the granite has been divided into six distinctive phases. In order of decreasing age these include: fine and medium grained diorite (Unit 3), foliated, coarse grained porphyritic granodiorite (Unit 4), foliated, variably porphyritic granite and adamellite (Unit 5), locally foliated, pink, phenocryst rich, biotite granite (Unit 6), locally foliated, red, coarse grained, porphyritic adamellite and granite (Unit 7), and foliated and massive equigranular biotite ± muscovite granite (Unit 8).

Unit 3

Unit 3 is the least extensive phase of the Burgeo granite, underlying a total exposed area of less than 0.5 km^2. The unit is best exposed on several islands southwest of Burgeo. It consists of dark green and gray, fine to medium grained hornblende diorite. Near its contacts with porphyritic granodiorite (Unit 4), the diorite is agmatized.

The unit is not in contact with either of units 1 or 2, and the relationship between the diorite and the migmatites is unknown. Diorite underlies a small island several metres away from exposures of Unit 1 migmatite. If this diorite is part of Unit 3, then the close spatial association may indicate that the diorite and migmatites are related. Alternatively, it may be a large block within the agmatites, genetically unrelated to the later diorite of Unit 3.

Unit 4

Unit 4 is the most extensive phase of the Burgeo granite, constituting approximately 50 percent of the granite's area. Well exposed throughout, it underlies much of the area north of Connoire Bay, the area in and around Kings Harbour Brook, the area north and east of Big Barasway, and in and around the community of Burgeo.

Unit 4 contains a distinctive, xenolith-rich phase (subunit 4a). Pink aplite (4b) and granite pegmatite (4c) dikes are widespread and diagnostic of the unit.

Unit 4 consists mainly of biotite rich granodiorite and minor amounts of adamellite, which form characteristically knobby, white or gray weathering exposures. The granodiorite is either light to dark gray, mottled black and white, or pale red, with either white or pink phenocrysts (Plate 7). It is generally porphyritic, with 2-4 cm subhedral K-feldspar phenocrysts in a quartz, plagioclase, biotite ± sphene ± rare hornblende groundmass. Biotite is a major component, locally constituting up to 40% of the mode. The groundmass grain size is variable and gradationally between 2 mm and 1 cm. The proportion of phenocrysts to matrix is variable, with phenocrysts constituting between 10% and 30% of the rock. Rarely the granodiorite is essentially free of phenocrysts. Chloritized biotite, cloudy quartz and sericitized feldspar are typical alteration features. Unit 4 granodiorites and adamellites are either xenolith free or contain up to 5% xenoliths of either diorite, quartz diorite or gabbro. It is also weakly to strongly foliated, locally displaying a cataclastic fabric.

Plate 7: *K-feldspar porphyritic granodiorite, Unit 4 of the Burgeo granite.*

Unit 4a is a coarse grained, porphyritic granodiorite rich in mafic xenoliths. It forms a 0.5 to 1.0 km, roughly east-west trending zone within Unit 4 granodiorite; its contact with that phase is gradational. With the exception of the xenoliths, it is lithologically the same as Unit 4. The phase contains from 5 to 50 percent, characteristically flattened, gabbro, diorite and quartz diorite xenoliths from a few centimetres to 1 metre in length (Plate 8). While most xenoliths have sharp, rounded boundaries, some are partially assimilated into the granodiorite.

Plate 8: *Xenolith-rich granodiorite, Unit 4a of the Burgeo granite. Width of field of view is approximately 10 m.*

Units 4b and 4c are composed of dikes of aplite and pegmatite respectively, which intrude units 4 and 4a. The aplite is pink, fine grained and rarely quartz porphyritic, commonly sheared or brecciated, and form both distinct dikes and network vein systems. The pegmatite is composed of quartz and K-feldspar, with or without plagioclase, muscovite and biotite. They form pegmatitic or monomineralic segregations, veinlets and sharply bounded dikes.

Units 4 and 4a show both intrusive and gradational relationships with Units 1 and 1a and are intrusive into Units 2 and 3. The contact between Unit 4 and Unit 1 migmatite near Grandy's Brook is locally represented by a zone, several tens of metres wide, where the migmatite is cut by dikes and variably shaped plugs of porphyritic granite. In the same area, however, the granodiorite contains partially assimilated magnetite rich metabasic xenoliths near the contact. The granodiorite is gradational with finer grained, recrystallized, equigranular granitoid, similar to the migmatitic granitoids of Unit 1. This zone appears gradational into inclusion rich migmatite of Unit 1. The gradational nature of the contact between the granite and the migmatite suggests that migmatite formation and early plutonism are essentially contemporaneous, and that the migmatites may represent deep levels of the Burgeo granite.

The contact between Units 4 and 1a is marked by a hybrid zone of granodiorite, nebulitic migmatite and equigranular granite. The granodiorite locally grades into nebulitic granitoid migmatite (orthogneiss) over a distance of 1 m.

The contact between Units 4 and 2 is sharp and intrusive in nature. The contact of units 4 and 3 is similar, and is locally marked by a narrow (approximately 10 m) zone of agmatite.

Unit 5

Unit 5 is a granite-adamellite phase which is spatially associated with Unit 4. Unit 5 intrudes Unit 4 in most areas, but locally the contact is gradational. This phase includes equigranular biotite rich adamellite, equigranular granite, variably porphyritic granite and adamellite, and dikes of aplite and fine grained leucocratic adamellite. It differs from Unit 4 in that it: (1) is lithologically more diverse; (2) is more granitic in composition; (3) is either equigranular or more sparsely porphyritic; (4) generally contains less biotite; and (5) contains fewer xenoliths. Typical exposures are gray, pale pink or pale red and lack the knobby appearance of Unit 4. Porphyritic varieties usually contain either between 1 and 5 percent or 10 and 15 percent phenocrysts; rarely, up to 40 percent phenocrysts have been noted. The phenocrysts vary from 0.5 cm to 2 cm in length and are irregularly dispersed in a fine to medium grained groundmass of quartz plus K-feldspar, with or without biotite, sphene and rare muscovite. On average the unit is less melanocratic than Unit 4, with 3 percent to 5 percent biotite being characteristic. Equigranular varieties are medium to coarse grained and in many places are gradational into porphyritic granite. Locally the granite is more biotite rich, containing small (less than 50 cm^2) cognate zones of quartz diorite and tonalite. Unit 5 is pervasively foliated and metamorphosed.

Dikes of sparsely porphyritic aplite and granite, presumably related to Unit 5, cut porphyritic granodiorite of Unit 4. In other areas the contact appears to be gradational, and is based largely on a gradual decrease in phenocryst population from Unit 4 into Unit 5.

Unit 6

Unit 6 is a phenocryst-rich granite phase of the Burgeo granite, tentatively interpreted to be partly equivalent in age to Unit 5. It is exposed along the coast between Connoire Head and Big Barasway, northwards to Cobbler Hill, and in isolated stocks near Muddy Hole Bay and northeast of Connoire Bay. The granite is mainly medium to coarse grained, porphyritic, biotite-bearing and characteristically rich in euhedral, equant, 1-2 cm K-feldspar phenocrysts (Plate 9). It is pink or red, with diagnositc pink or pink and white, rapikivi-textured K-feldspar phenocrysts.

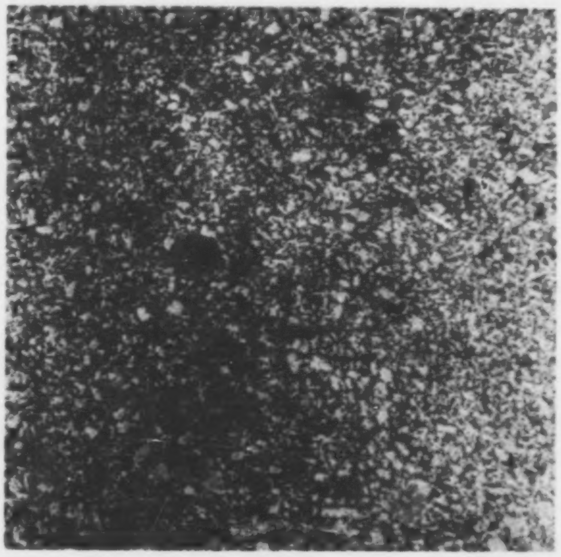

Plate 9: *K-feldspar porphyritic granite, Unit 6 of the Burgeo granite.*

Locally, textural variations occur, and the porphyritic phase is gradational into smaller zones of coarse grained equigranular granite. Pink, fine grained, equigranular granite and aplite dikes are widespread within the unit. Aside from a smaller modal proportion of biotite, Unit 6 is mineralogically similar to Units 4 and 5. The unit appears to lack the pervasive foliation and extensive metamorphism of earlier phases. It is, however, foliated locally, and is also sheared and brecciated along late northeast and northwest trending faults.

Unit 7

Unit 7 includes porphyritic granite and adamellite, that form a 10 km^2 boss east of Bay de Loup. Characteristically, it is either pink, orange or red, medium to coarse grained, K-feldspar porphyritic and generally phenocryst rich. The unit locally contains xenoliths and large (approximately 100 m^2), stoped rafts of diorite. It is foliated and brecciated along a major northeast trending fault which passes through Bay de Loup. This fault separates Unit 7 from the remainder of the Burgeo granite, thus its temporal relationship to Units 4, 5 and 6 is uncertain.

Unit 8

Unit 8 includes the equigranular tured granitic phases of the Burgeo granite. These occur throughout the map area, forming more than a dozen separate bosses ranging in area from less than 1 km^2 to approximately 20 km^2. On the basis of color, biotite content and the presence or absence of xenoliths, the equigranular phases can be divided into two subunits.

Unit 8 consists of granite, adamellite, microgranite and aplite. These are either white to pink or light gray, and either fine, medium or coarse grained, and free of xenoliths (Plate 10). The granitoids are typically rich in K-feldspar and quartz, and contain variable amounts of biotite plus muscovite and garnet locally. Estimated modal biotite content is normally between 1 percent and 5 percent, but locally reaches up to 15 percent.

Unit 8 is typically equigranular; however, there is a slight, gradational increase in its K-feldspar phenocryst content towards the contact with Unit 5. Unit 8 lacks the ubiquitous foliation of Unit 4, but is affected locally by the regional deformation.

Unit 8a outcrops in the vicinity of Six Mile Hill, west of Grandy's Brook. It consists of light to dark gray, foliated, equigranular, biotite ± muscovite granite and granodiorite. Unit 8 contains numerous diorite xenoliths. Unit 8a is presumed to be intrusive into Unit 5; it intrudes and is in fault contact with Unit 4.

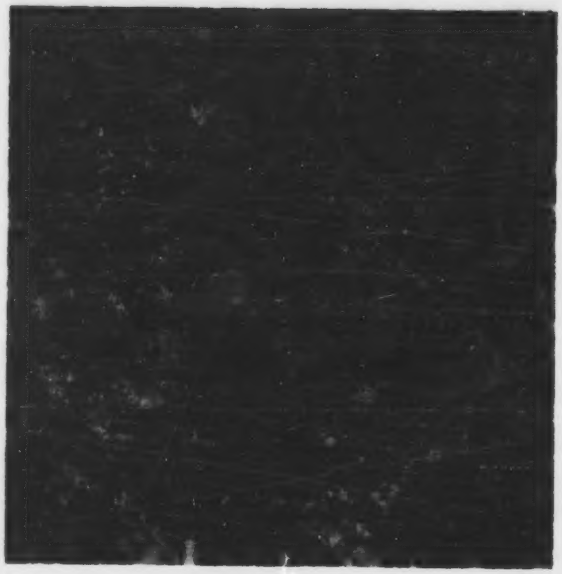

Plate 10: *Equigranular granite, Unit 8 of the Burgeo granite.*

Unit 8 intrudes Units 1a, 4 and 5. Its contacts with 1a and 4 are sharp; both units are cut by narrow dikes of Unit 8. Both dikes and country rocks are at least locally affected by the same regional foliation. Although crosscutting relationships are seen locally, the contact of units 5 and 8 is generally gradational, marked by a gradual increase in phenocrysts from Unit 8 into Unit 5.

Chetwynd granite (Unit 9)

The name Chetwynd granite (Cooper, 1954) denotes the late to posttectonic granite which intrudes the Burgeo granite in the west-central parts of the map area. These rocks form the eastward extension of the granite from its type exposures in the La Poile area (Chorlton, 1978). The granite underlies approximately 75 km^2 of the Bureo area, and is intrusive into Units 4, 5 and 6 of the Burgeo granite.

The Chetwynd granite has yielded zircons dated at 377 ± 20 Ma (Dallmeyer, 1980). $^{40}Ar/^{39}Ar$ spectra for biotite from the granite in the adjacent La Poile area indicate a cooling age of 372 ± 5 Ma for the Chetwynd granite (Dallmeyer, 1980).

The Chetwynd granite, undivided in the Burgeo map area, is a high level, essentially massive, quartz rich granite. It is either pink or red and locally white weathering. It is texturally variable but mainly medium to coarse grained and equigranular. Locally, the granite contains zones that are fine grained quartz porphyritic, fine grained K-feldspar porphyritic, or rapikivi textured. The granite is characteristically leucocratic, with less than 1-2% modal biotite. It contains rare granitoid xenoliths and is, in places, miarolitic. The Chetwynd granite is essentially posttectonic, and intrudes the Burgeo granite after the main regional deformation. Structurally, it is characterized by a pronounced northeast trending parallel joint system;it is cut by several late faults which have little obvious displacement. The granite is intrusive into Units 4, 5 and 6 of the Burgeo granite and contains variably sized inclusions of Unit 1a metasediments, migmatites and diorite. Near the west boundary of the map area, the granite contains inclusions and small roof pendants of felsic tuff and tuffaceous sediments; these are presumably related to the La Poile Group to the west (e.g. Chorlton, 1978). A zone of network veins, dikes and stocks of Chetwynd granite intrude the Burgeo granite at the contact; the contact zone is of variable extent, in places over 1 km wide.

Units 10 and 11

These units consist of late, posttectonic dikes, which intrude the Chetwynd and Burgeo granites and the earlier migmatites. Unit 10 is composed of pink, leucocratic, fine grained, quartz and feldspar porphyritic, granite dikes. These are widely distributed and vary widely in orientation. They are locally continuous along strike for several hundreds of metres and have characteristically straight, sharp boundaries.

Unit 11 consists of diabase dikes. These are less widespread than the quartz-feldspar porphyry dikes and are dark gray, massive, and fine to medium grained.

MINERAL EXPLORATION POTENTIAL

Within the Burgeo map area, the Chetwynd granite has the greatest potential for granite hosted mineralization. It is high level, highly differentiated, potassic, and quartz rich, and thus potentially geochemically specialized. The Sn-W-F-Mo-U potential of the granite should be considered, especially since there are multi-element lake sediment geochemical anomalies near its margins (Butler and Davenport, 1980).

The latest phases of the Burgeo granite, particularly Unit 8, have a potential for molybdenite mineralization as well as related Sn-W-F mineralization. Molybdenite occurs in equivalent units in the adjacent Peter Snout map area (11P/13), two kilometers north of the Burgeo map area (O'Brien, 1983). Elsewhere in the Burgeo granite, pegmatite dikes are widespread; these may be of some economic interest.

Screens of rhyolite tuff of the La Poile Group within the Chetwynd granite may indicate that volcanic rocks are present elsewhere within the granite, and are more extensive than previously thought. This is of particular interest in the light of recent gold discoveries within the La Poile Group, adjacent to the Chetwynd granite, 6 km west of the Burgeo map area (Northern Miner, August 30, 1984).

SUMMARY

The oldest rocks in the region are the migmatites. In the north they are metasedimentary in origin, related to the upper amphibolite facies metamorphism and local partial melting which accompanied the main regional deformation. Their protolith is presumably the metasedimentary rocks of the mid-Ordovician Bay du Nord Group or its equivalents. The southern migmatite zone has in part an igneous protolith; in the least remobilized zones, inclusions of layered and banded gabbro are recognizable. The protolith of the mafic rocks in the inclusions is equivocal and may be related to either early mafic phases of the Burgeo granite or to Lower Ordovician or earlier metagabbros interpreted as ophiolitic basement to the Bay du Nord Group in the White Bear River area to the north (O'Brien and Tomlin, 1984). The formation of the migmatites is considered to be essentially contemporaneous with early synkinematic plutonism of the Burgeo granite, in the early Silurian. The locally gradational contact between the migmatites and the earliest xenolith rich granodiorite phase of the Burgeo granite may indicate that these migmatites represent deep levels or parts of the root zone of the Burgeo granite.

Early to mid-Silurian magmatism produced several texturally and mineralogically distinct granitoid phases. In general, these become progressively more granitic with time. However, the existence locally of both crosscutting and gradational relationships between the same two phases indicate that some of the magmatic pulses are in part contemporaneous and of variable duration. The major phases are variably deformed, and in places relatively massive; this style of deformation is in keeping with the synkinematic nature of the Burgeo granite (e.g. Blackwood, 1984; O'Brien and Tomlin, 1984).

Late Silurian - Devonian magmatism resulted in the emplacement of essentially posttectonic quartz rich, potassic, high level granite, associated felsic porphyry dikes and diabase. The Chetwynd granite was emplaced circa 372±5 Ma (Dallmeyer, 1980); this age date represents an upper time limit on the regional deformation and a minimum age for the Burgeo granite. The greatest potential for economic mineralization lies within the Chetwynd granite.

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GEOLOGY OF THE WEST HALF OF THE BURNT POND MAP AREA (12A/3), SOUTH-CENTRAL NEWFOUNDLAND

by

S.J. O'Brien and S.L. Tomlin

ABSTRACT

The map area lies within the Dunnage Zone of the Newfoundland Appalachians, and is located in the north-central part of the Hermitage Flexure. The oldest of the area's components are the mid-Ordovician polyphase deformed and metamorphosed sedimentary rocks of the Bay du Nord Group and migmatites of enigmatic origin. Both are intruded by the polyphase, Siluro-Devonian North Bay Granite. A major aeromagnetic linear separates the equigranular and earlier porphyritic phases of the granite. It is thought that the Bay du Nord Group was deformed and metamorphosed under upper greenschist to amphibolite facies conditions prior to and during the earliest magmatism of the North Bay Granite. Subsequent phases are late tectonic. The youngest equigranular granite phases are quartz rich and muscovite bearing, and have the potential of hosting Sn-W-Mo-U-F mineralization.

INTRODUCTION

The western half of the Burnt Pond map area is located in south-central Newfoundland and is bounded by 57°15' and 57°30' west longitudes and 48°00' and 48°15' north latitudes (Figure 1). From mid summer and autumn, the area is accessible by the private roads of Newfoundland and Labrador Hydro and Abitibi-Price Newfoundland Limited; access beyond the Granite Lake west dam requires the prior approval of Newfoundland and Labrador Hydro.

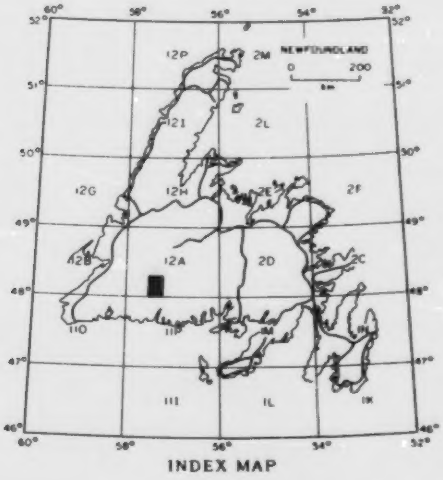

Figure 1: *Location of the study area.*

The area contains little bedrock exposure and is physiographically characterized by a boggy, flat to gently rolling topography (ca. 300-350 m), broken by widely scattered monadnocks (ca 450 m. asl.). The southern part of the area is topographically higher (350-450 m) and more irregular than the north. Original drainage patterns have been drastically altered during flooding by Newfoundland and Labrador Hydro in the late 1960's.

Previous geological investigations in the area include reconnaissance mapping by the Buchans Mining Company (Scott and Conn, 1950) and 1:250,000 scale mapping by the Geological Survey of Canada (Riley, 1957). A project of limited geological reconnaissance together with map compilation was carried out by Smyth (1979). The area was covered by the regional lake bottom sediment sampling program of the Newfoundland Department of Mines and Energy (Butler and Davenport, 1980). The eastern half of the Burnt Pond map area was mapped at a scale of 1:50,000 by Dickson (1982) and 1:50,000 scale mapping of the westerly adjacent King George IV map area was completed by Kean (1983).

GENERAL GEOLOGY

The area forms part of the north-central Hermitage Flexure of the Dunnage Zone of the Newfoundland Appalachians, and is underlain by granitoid rocks of the North Bay Granite (Jewell, 1939) and metasedimentary rocks of the Bay du Nord Group (Dorf and Cooper, 1943; Cooper, 1954). The area can be divided into three components which form separate northeast to east trending belts (Figure 2). The southernmost component comprises mainly polydeformed, upper greenschist to amphibolite facies schists and metasediments (Units 1 and 2), which are intruded posttectonically by an equigranular granite stock (Unit 7). The central component comprises foliated, coarse grained, porphyritic granodiorite and granite (Unit 4) that intrude or are faulted against the metasedimentary rocks. In the contact zone, granites and metasediments are both affected by the regional foliation. A major aeromagnetic lineament separates the granitoids of the central

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

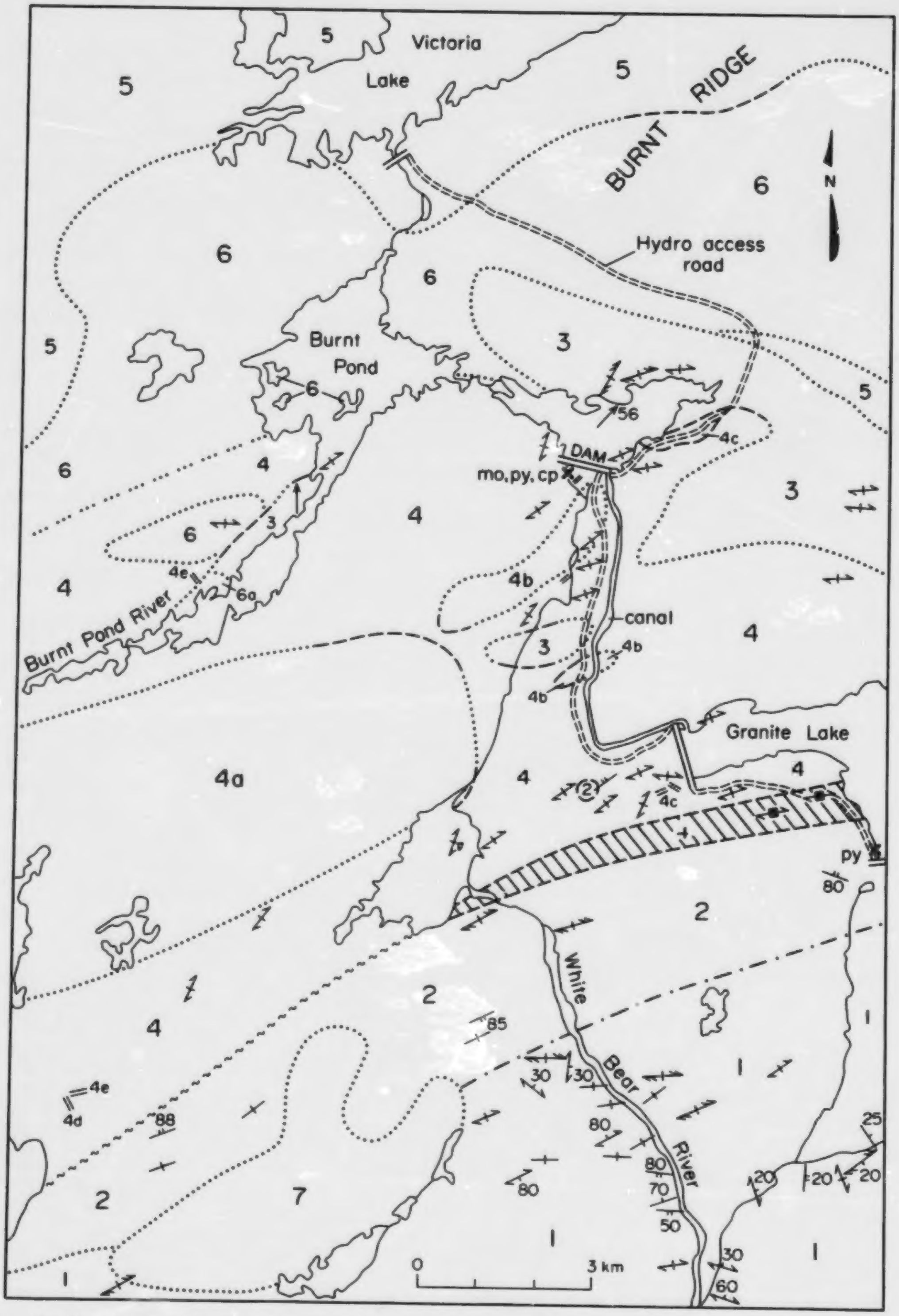

Figure 2: *Geological map of the western half of the Burnt Pond (12A/3) map area, Newfoundland.*

LEGEND

DEVONIAN OR EARLIER

NORTH BAY GRANITE (Units 4 to 7)

7 *Buff to pink essentially massive, fine to medium grained, equigranular to quartz porphyritic, biotite ± muscovite granite.*

6 *Buff to pale pink massive to weakly foliated, fine to medium grained, equigranular, biotite ± muscovite granite; hornblende and tourmaline-muscovite-garnet bearing pegmatite;* **6a**, *dark gray, fine to medium grained, equigranular, biotite-rich granite.*

5 *Buff to white, weakly foliated, medium to coarse grained, equigranular to sparsely porphyritic, biotite granite.*

4 *Gray and pale pink, foliated, coarse grained, K-feldspar porphyritic to megacrystic, biotite granite and granodiorite;* **4a**, *unseparated, coarse grained porphyritic and equigranular biotite granite;* **4b**, *coarse grained, K-feldspar porphyritic, biotite granodiorite containing cognate xenoliths of diorite;* **4c**, *coarse grained, porphyritic, biotite granite with screens of paragneiss and metasedimentary rocks;* **4d**, *fine to medium grained diabase;* **4e**, *pink and gray aplite.*

ORDOVICIAN OR EARLIER

3 *Migmatite, psammite, paragneiss and granitoid.*

LOWER TO MIDDLE ORDOVICIAN

BAY DU NORD GROUP

2 *Gray to green shale, siltstone, sandstone, phyllite and psammite; minor thin tuff beds.*

1 *Pelite, semi-pelite and biotite schist with granitoid and quartz segregations.*

component from a northernmost component of porphyritic and equigranular granite and migmatite. In the northern zone, the migmatite and associated equigranular granitoids (Unit 3) are intruded by foliated porphyritic granodiorite and granite (Unit 4) and by foliated to massive equigranular to variably porphyritic granite and pegmatite (Units 5 and 6).

Bay du Nord Group (Units 1 and 2)

The Bay du Nord Group was defined by Dorf and Cooper (1943) and Cooper (1954) as the dominantly metasedimentary rocks exposed between La Poile Bay and Garia Bay on the southwest coast of Newfoundland. As originally defined, the group contained a fossiliferous sedimentary succession of Devonian age. Chorlton (1980) redefined the Bay du Nord Group, removing from it the fossiliferous section; the remaining metasedimentary and metavolcanic rocks were reassigned to the Ordovician. Subsequent mapping by Kean (1983), O'Brien (1983) and O'Brien and Tomlin (1984) has extended the group northeastwards into the present map area.

In the western half of the Burnt Pond area, the group is comprised mainly of pelitic to semi-pelitic, upper greenschist to amphibolite facies metasediments. On the basis of relative metamorphic grade, the group can be divided into two units.

Unit 1

Unit 1 consists mainly of highly contorted phyllites, semi-pelite, pelite and biotite schist, with minor siltstone and shale; quartz veining and incipient migmatization is widespread throughout. The metasediments are dark gray, black or green, locally rusty weathering, and either laminated, thinly bedded or massive. Quartzofeldspathic beds may be locally granoblastic. A fine penetrative foliation, often coplanar to bedding, is essentially ubiquitous. Locally, the fabric is parallel to the axes of early small scale folds. Refolding is widespread and accompanied locally by the transposition of S_1 by second generation cleavage. In places, granitic veins and quartz rich segregations impart a migmatitic appearance to Unit 1.

Unit 2

Unit 2 consists mainly of black, gray or locally buff, mainly fine grained clastic sedimentary rocks of lower to upper greenschist facies metamorphic grade. Shale, siltstone, sandstone, phyllite and psammite are diagnostic rock types; these occur together with rare coarse grained sandstone and conglomerate. Quartzofeldspathic arenite and lithic tuff in beds up to 20 cm thick are present, but uncommon. The sedimentary rocks are characteristically either black, gray or locally buff, and fine grained. In most areas, the sediments form thin parallel beds and laminae; only rarely are they massive and thickly bedded (Plate 1). Sandy beds are locally cross-stratified. Adjacent to the granitoids, the sedimentary rocks are either massive, featureless hornfels or staurolite bearing schist. Unit 2 lacks the pervasive quartz veining and incipient migmatization diagnostic of Unit 1. Unit 2 is variably deformed, with an early fabric refolded on steep, upright, axial planes. The second deformation also produced a variety of kinks, crenulations and brittle structures within both Units 1 and 2.

Plate 1: *Thinly bedded sandstone and shale, Bay du Nord Group.*

The contact of Units 1 and 2 is gradational over a distance of several hundred metres, marked by a gradual decrease in metamorphic grade and the degree of metamorphic remobilization from Unit 1 into Unit 2.

Unit 3

Unit 3 denotes a zone of migmatite and associated granitoid rocks which is intruded by younger phases of the North Bay Granite. The zone is poorly exposed, and inferred to underlie approximately 20 km^2 north and east of Burnt Pond. Equivalent rocks underlie a narrow area immediately northwest of the steadies on Burnt Pond River.

The migmatites have irregularly developed stromatic and schlieren structures (Plate 2). Layering of biotite-rich, sillimanite-bearing bands and equigranular granitoid is of variable width, but is commonly between 2 and 5 mm. The proportion of paleosome is variable, and the migmatites, in places, are comprised almost entirely of nebulitic granitoid leucosome. The migmatites contain psammitic xenoliths that display various degrees of assimilation with the leucosome. In places the xenoliths have polydeformed internal foliations (Plate 3); elsewhere they form indistinct zones within the migmatite, and have a fabric which is roughly concordant with that in the leucosome. The migmatites are intruded by the younger porphyritic and equigranular phases of the North Bay Granite.

Plate 2: *Migmatized metasedimentary rocks, Unit 3.*

Plate 3: *Refolded structures in psammitic xenolith, Unit 3.*

North Bay Granite (Units 4 to 7)

The name North Bay Granite (Jewell, 1939) denotes the large composite granitoid batholith which lies to the north of and intrudes the Bay du Nord Group along the central and eastern parts of the Hermitage Flexure. In the western half of the Burnt Pond area, the granite can be divided into four distinctive units, based on texture, mineralogy, degree of deformation and field relationships. These include: foliated porphyritic biotite granite and granodiorite (Unit 4); foliated coarse grained equigranular to variably porphyritic biotite granite (Unit 5); foliated to massive equigranular biotite ± muscovite granite (Unit 6), and massive, quartz-porphyritic to equigranular biotite ± muscovite granite (Unit 7).

Unit 4

Unit 4 comprises the foliated, coarse grained porphyritic, biotite granite and granodiorite that underlies much of the central part of the map area. Locally, it is divisible into subunits that are characterized by either: (a) their association with small amounts of equigranular granitoid (Unit 4a), (b) the presence of numerous diorite xenoliths (Unit 4b), or (c) the presence of screens of either metasediment or paragneiss (Unit 4c). Another diagnostic feature of Unit 4 is the presence of dikes of diabase (Unit 4d) and aplite (Unit 4e).

Unit 4 granite and granodiorite is either gray or very pale pink with pink or white K-feldspar phenocrysts and megacrysts (Plate 4). It is characteristically phenocryst rich, but may locally contain diffuse bands with relatively few phenocrysts. Grain size is characteristically coarse. Locally, two phenocryst size populations are developed: 1-2 cm and 4-5 cm. In places, megacrysts up to 8 cm were noted. Phenocrysts are either equant or subhedral to anhedral, and are zoned in places (Plate 5).

Diorite, metasediment and paragneiss are present as inclusions in the granite and granodiorite. The diorite xenoliths, presumably of cognate origin, vary from a few centimeters to 1.5 meters in maximum dimension (Plate 6). Their boundaries may be either sharp or diffuse, and the xenoliths have an internal foliation parallel to that in the enclosing granite. The metasedimentary inclusions are variable in size, and contain the regional foliation seen in the adjacent granite. The paragneiss has a previously deformed biotite rich banding and has undergone a different style of deformation than the surrounding granite.

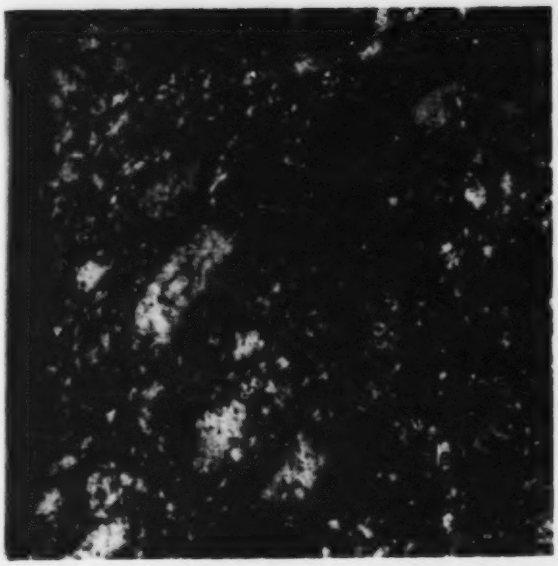

Plate 4: *K-feldspar porphyritic, biotite granite, North Bay Granite (Unit 4).*

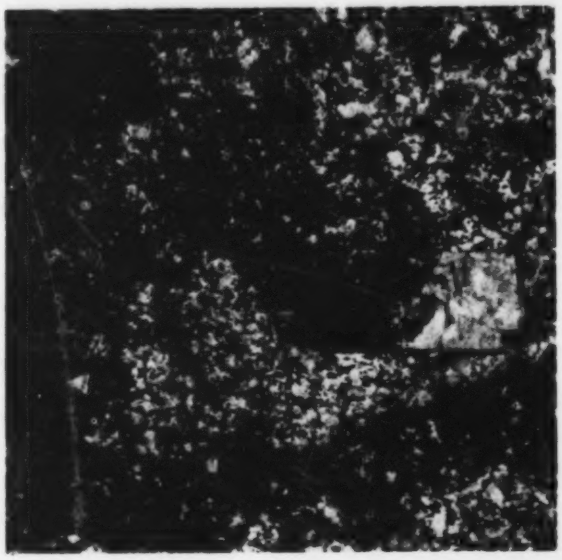

Plate 5: *Zoned K-feldspar megacryst in porphyritic, biotite granite, North Bay Granite (Unit 4).*

Unit 4 has a variably developed foliation which, although seen in most areas, is not everywhere penetrative. The regional foliation in the unit increases in intensity southwards, where it has a strong cataclastic component. Adjacent to the contact with the Bay du Nord Group, a protomylonite zone is developed in the granite. At the Granite Lake (west) Dam, the porphyritic granite and aplites which intrude

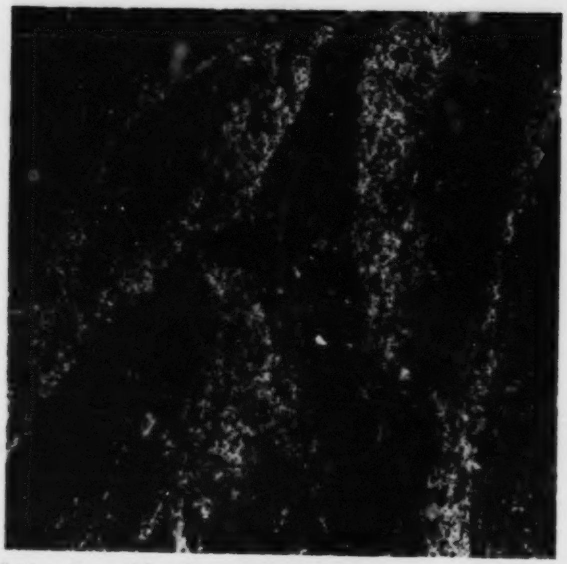

Plate 6: *Diorite xenoliths with K-feldspar porphyroblasts, North Bay Granite (Unit 4b).*

it are affected by brittle structures, and brecciation accompanied by extensive chlorite and hematite alteration is widespread.

Unit 4 posttectonically intrudes the migmatites of Unit 3. Although much of the contact between Units 2 and 4 is either faulted or unexposed, the presence of large xenoliths of metasediment in the granite immediately north of the assumed contact indicates an originally intrusive relationship. In the contact area, both granite and metasediment are affected by the regional deformation.

Unit 5

Unit 5 comprises the weakly foliated, medium to coarse grained, equigranular and medium grained, variably porphyritic biotite granite, which underlies the northernmost parts of the map area. Due to poor exposure, the unit cannot be further subdivided.

On the northern part of Burnt Ridge, the unit consists of weakly foliated, buff, medium grained, equigranular biotite granite. In places this granite contains 1-2 percent K-feldspar phenocrysts. A similar rock type forms the only exposure of this unit found west of Burnt Pond. Buff to white, medium grained, porphyritic, biotite-poor granite is exposed in the central part of the area underlain by Unit 5. Here, the granite is spatially associated with medium grained, sparsely porphyritic biotite granite. Coarse grained equigranular to sparsely porphyritic, biotite granite, exposed approximately 1 km northeast of the eastern end of Burnt Pond, is tentatively included with Unit 5.

The contact of Unit 5 with adjacent units is unexposed, thus the nature of its relationship to other phases of the North Bay Granite is uncertain. Its granitic composition and its spatial association with Unit 6 may indicate a genetic link with that phase.

Unit 6

Unit 6 is a fine to medium grained equigranular granite, which lies to the north of Units 3 and 4 and which is bounded to the north by Unit 5. It is exposed only on the southern part of Burnt Ridge and on the Victoria Dam access road. A distinctive aeromagnetic low over much of the area west of Burnt Pond is taken as evidence that Unit 6 underlies much of this drift and swamp covered area.

The typical rock type of this unit is a massive to weakly foliated, buff to pale pink, equigranular biotite ± muscovite granite. It is usually massive in outcrop but is locally foliated. In places it is cut by rare hornblende-bearing appinitic sweats and pegmatite dikes. Tourmaline-muscovite-garnet pegmatites are spatially associated with dikes of Unit 6 which intrude Units 3 and 4, near the eastern end of Burnt Pond (Plate 7). It is assumed that these latter pegmatites are also genetically related to Unit 6.

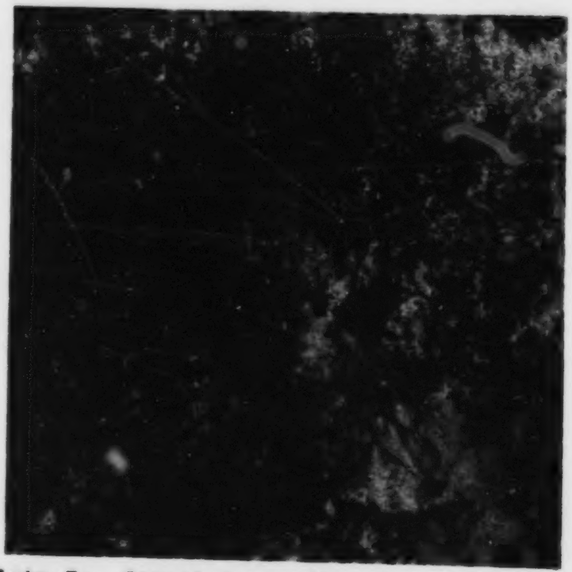

Plate 7: *Garnet-muscovite-tourmaline bearing granite pegmatite associated with Unit 6 of the North Bay Granite.*

Dikes of medium grained equigranular, biotite ± muscovite granite intrude the migmatites of Unit 3. These dikes are post-tectonic with respect to the deformation seen in the migmatites. Dikes of the same composition intrude porphyritic granodiorite of Unit 4. Locally, both dike and host rock share the same regional foliation. The contact of Unit 6 with Unit 5 is unexposed and their relationship is unknown.

Unit 7

Unit 7 is a small granite plug, separate from the main body of the North Bay Granite, which intrudes the Bay du Nord Group. Its lithology is fine to medium grained buff to pink equigranular to quartz porphyritic leucocratic biotite ± muscovite granite. The granite lacks a pervasive foliation but is affected by narrow shear zones along which a cleavage is locally developed.

The unit has intruded the Bay du Nord Group after the first and main deformation. Dikes of this granite in the metasediments are affected only by the second phase folds of cleavage.

MINERAL POTENTIAL

The map area has potential for both sediment hosted and granitoid related mineralization. Within the Bay du Nord Group (Units 1 and 2), pyrite mineralization is widespread, and a potentially significant pyritiferous gossan is developed over black slate and pelitic schist at Goodyears Dam on the south side of Granite Lake.

Uranium mineralization occurs in Bay du Nord Group sediments approximately 3 km south of the Burnt Pond map area (O'Brien and Tomlin, 1984, this volume). The uranium occurs in both pelitic schist and tuffaceous metasediments. Both rock types occur within Units 1 and 2 in the Burnt Pond area, and these units have potential of hosting similar mineralization.

The North Bay Granite in the Burnt Pond area contains small showings of pyrite, chalcopyrite and molybdenite, and has a potential for tin, tungsten, fluorine and uranium mineralization. In the hydro canal immediately south of the dam on Burnt Pond, Unit 4 porphyritic granite is cut by dikes of Unit 6 equigranular granite. There, fractures in the porphyritic granite are partially coated by pyrite, chalcopyrite and molybdenite mineralization.

Significant Mo-W mineralization occurs in the North Bay Granite near the eastern end of Granite Lake, approximately 40 km to the east (Dickson, 1982). There sparse, disseminated molybdenite occurs in granite dikes, quartz veins and pegmatites, which cut altered muscovite-biotite granite. Wolframite and scheelite (0.1 to 2 percent WO_3) occur in quartz veins near the contact between muscovite-biotite granite and biotite granodiorite. Immediately east of the western half of the Burnt Pond map area, lake sediment molybdenum anomalies occur over the equivalents of Unit 5 (Butler and Davenport, 1980). Boulders of equigranular granite with tourmaline and minor molybdenite disseminations were found in the easternmost part of the area, and suboutcrop of Unit 5 with minor tourmaline and molybdenite-coated fractures was seen approximately 500 m east of the map area. Tourmaline-muscovite-garnet pegmatites and quartz-rich segregations occur in Units 3 and 4 close to the contact with Unit 5 near the east end of Burnt Pond. These dikes are presumed to be related to Unit 5, and have good potential for tungsten mineralization.

SUMMARY

The major geological components of the map area are the Ordovician Bay du Nord Group, the Siluro-Devonian(?) North Bay Granite, and migmatites of equivocal age and origin. The Bay du Nord Group represents a period of Middle Ordovician distal marine sedimentation accompanied by limited volcanism. These rocks were first deformed and metamorphosed under upper greenschist to amphibolite facies conditions prior to and in part during the intrusion of the early porphyritic phases of the North Bay Granite. Subsequent equigranular phases of the granite are late synkinematic to post-tectonic with respect to the major tectonothermal event affecting the sedimentary rocks. The youngest phase of the granite cross cuts S_1 in the metasediments; dikes of this phase are affected by open upright F_2 folds.

The protolith of the migmatites in the North Bay Granite is uncertain. In the adjacent King George IV map area, Kean (1983) demonstrated that migmatites there were related to high grade metamorphism of the Bay du Nord Group. It is thought that the migmatites represent higher metamorphic equivalents of the Bay du Nord Group rocks to the south, although there is no evidence in the map area which rules out another source for these rocks.

In light of the known occurrences of molybdenite, scheelite and wolframite showings elsewhere in the North Bay Granite (e.g. Dickson, 1982), the area can be considered to have good potential for granite hosted mineralization.

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URANIUM MINERALIZATION IN THE BAY DU NORD GROUP, SOUTHWEST NEWFOUNDLAND: A BRIEF NOTE

by

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ABSTRACT

Recently discovered radioactive zones within the mid-Ordovician Bay du Nord Group have yielded assays up to 4,330 g/t U. The main uranium phase is uraninite; it is concentrated in fine grained pelitic bands in staurolite schist and also in coarse grained, porous layers in an unwelded epiclastic volcanic rock. These new discoveries of syngenetic uranium mineralization, coupled with the existence of stratiform uranium occurrences elsewhere in group, indicate that the Bay du Nord Group and the southwestern Newfoundland Hermitage Flexure form a potentially significant, previously unrecognized, uranium province.

INTRODUCTION

Uranium mineralization in the mid-Ordovician Bay du Nord Group of southwestern Newfoundland was discovered during 1:50,000 regional mapping of the White Bear River (11P/14) map area (O'Brien and Tomlin, 1984). Outcrops of radioactive staurolite schist and a zone of radioactive boulders and suboutcrop of tuffaceous sediment, which locally yielded in excess of 10,000 c.p.s. (BGS-1 scintillometer), were discovered at two localities (grid references 770122 and 731131 respectively). At that time, the origin of the mineralization was uncertain. The authors assumed that the mineralization at that locality was genetically related to granitoid rocks, as the mineralized schists were spatially associated with nearby two-mica leucogranite dikes.

REGIONAL GEOLOGY

The Bay du Nord Group (Dorf and Cooper, 1943; Cooper, 1954) is a thick and extensive succession of Mid-Ordovician, polydeformed, amphibolite facies metasedimentary and metavolcanic rocks, whose regional exposure pattern defines the west-central part of the Hermitage Flexure (Williams et al., 1970) of the Newfoundland Dunnage Zone (Figure 1). In the central parts of the Hermitage Flexure, the Bay du Nord Group is either bounded by faults or intruded by two major synkinematic to post-tectonic granitoid plutons, the Burgeo and North Bay Granites. The group is also intruded by a suite of smaller late to post tectonic granitoids, which are areally confined within the boundaries of the volcano-sedimentary belt. The Bay du Nord Group consists of dominantly silicic flows and volcaniclastic rocks in its lower stratigraphic levels, overlain by a dominantly metasedimentary succession, within which occurs distinct felsic volcanic units of variable thickness (O'Brien, 1983; O'Brien and Tomlin, 1984; Blackwood, 1984).

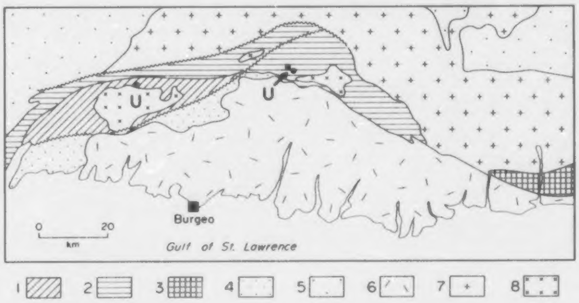
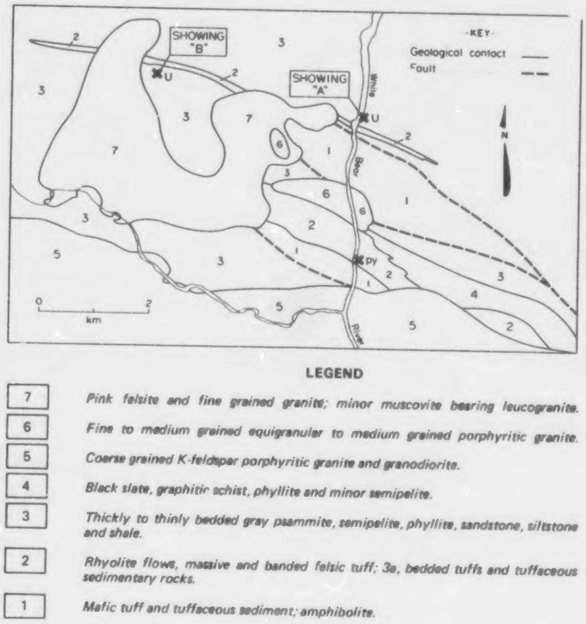


Figure 1: *Major geological elements of the Hermitage Flexure: 1: Bay du Nord Group - dominantly volcanic rocks, 2: Bay du Nord Group - dominantly sedimentary rocks, 3: Baie d'Espoir Group, 4: La Poile Group, 5: Undivided Paleozoic rocks, 6: Burgeo granite, 7: North Bay granite, 8: Post-tectonic granitoids.*

GEOLOGY OF THE SHOWINGS

Showing "A" (Figure 2) consists of radioactive staurolite bearing light to dark gray and black semi-pelitic schist of the Bay du Nord Group, exposed on the eastern shore of White Bear River. The radioactivity occurs over a width of approximately 30 cm, being concentrated in a zone of schist cut by quartz veins. The mineralized schists have a pronounced fabric defined by biotite and muscovite; quartzofeldspathic bands in the schist are granoblastically recrystallized. Staurolite porphyroblasts, up to 10 mm in length, overgrow the main fabric, but are affected by second generation folds and later quartz veining.

Showing "B" consists of large, tabular, radioactive boulders and radioactive suboutcrop located approximately four kilometres west-northwest of Showing "A". Several isolated radioactive boulders


SHOWING "B"
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LEGEND
7 Pink felsite and fine grained granite; minor muscovite bearing leucogranite.
6 Fine to medium grained equigranular to medium grained porphyritic granite.
5 Coarse grained K-feldspar porphyritic granite and granodiorite.
4 Black slate, graphitic schist, phyllite and minor semipelite.
3 Thickly to thinly bedded gray psammite, semipelite, phyllite, sandstone, siltstone and shale.
2 Rhyolite flows, massive and banded felsic tuff; 3a, bedded tuffs and tuffaceous sedimentary rocks.
1 Mafic tuff and tuffaceous sediment; amphibolite.

Figure 2: *Geology of the north-central White Bear River map area.*

were discovered over an area of a hundred or more square metres; the area of the main zone of boulders and suboutcrop is approximately 10 square metres. The mineralization occurs in fine to medium grained nonwelded quartz phyric tuffs which are either massive or display a crude primary layering of apparent epiclastic origin. They are dark gray on fresh surface, but previously buried boulders, when exposed for a period of a few months, have weathered yellow due to uranophane formation. The tuffs are recrystallized, and a granoblastic texture is developed. Subhedral, recrystallized quartz phenocrysts, from 1 to 2 mm in diameter, comprise up to 10% of the tuffs. The tuffs are biotite rich and fine grained biotite defines a weak foliation; coarser grained porphyroblasts are widespread.

The same tuffs, although not mineralized, are exposed approximately 1 km to the west of Showing "B". There, they form a distinct band, several tens of metres thick, associated with other rhyolitic tuffs. These volcanics are bounded stratigraphically by semipelitic schist of the Bay du Nord Group. The volcanic unit is exposed immediately north of Showing "B" and several tens of metres south of Showing "A" on White Bear River. The unit is very poorly exposed, but has been traced along strike for approximately 7 kilometres.

MINERALIZATION

Autoradiographs of mineralized samples from both showings indicate that the uranium mineralization is stratiform and strata-bound. In Showing "A", the uranium is concentrated in the finest grained pelitic bands of the staurolite schist (Figure 3a). Some remobilization of the uranium into quartz veins occurred during the deformation and accompanying metamorphism is evident. Uraninite is the main uranium phase; development of secondary uranophane is extensive. A grab sample of staurolite schist assayed 669 g/t U (Table 1).

In Showing "B", the uranium, although disseminated throughout much of the rock, is concentrated in the most porous zones of the tuff (Figure 3b). Further concentrations are parallel to primary banding in the tuff. The most radioactive boulders assayed 4330 g/t uranium (Table 1). No pitchblende was seen in hand specimen; x-ray diffraction studies, presently in progress, indicate that uraninite is probably the main uraniferous phase. Allanite is obvious in thin sections of the tuffs. As mentioned above, uranophane is also present.

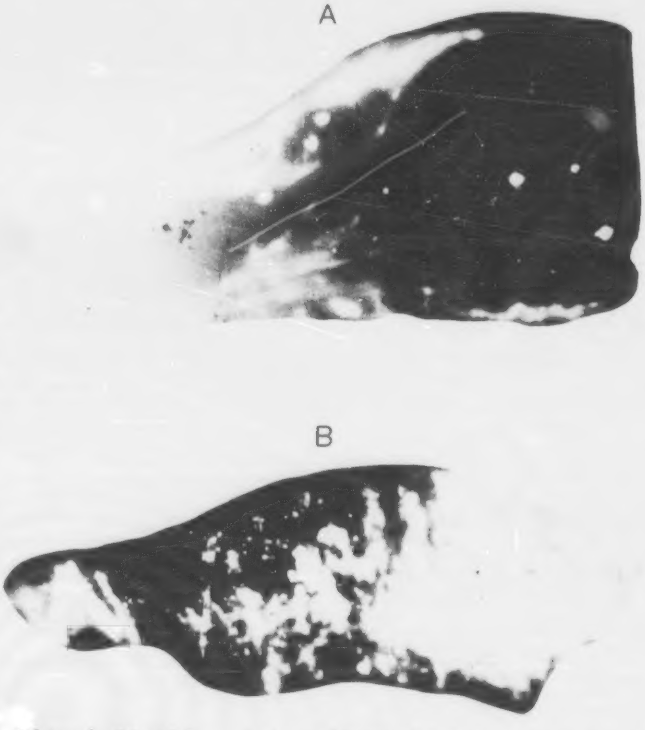

Figure 3(a+b): *Autoradiographs of mineralized samples of the Bay du Nord Group, White Bear River map area. A: staurolite schist with quartz veins, B: nonwelded tuff.*

SAMPLE NO.	ROCK TYPE	SHOWING	U g/t
1940601	nonwelded tuff	"B"	3,990
1940602	staurolite schist	"A"	669
1940603	nonwelded tuff	"B"	4,290
1940604	nonwelded tuff	"B"	4,240
1940605	nonwelded tuff	"B"	4,330
1940606	nonwelded tuff	"B"	4,240

Table 1: *Uranium assays (N.A.A.) of grab samples from radioactive zones in the Bay du Nord Group, White Bear River map area.*

SUMMARY AND CONCLUSIONS

Recently discovered uranium mineralization in the mid-Ordovician Bay du Nord Group is stratiform in nature and is interpreted to be essentially syngenetic. The mineralization is present, locally, where felsic volcaniclastic rocks are interbedded with fine grained pelitic metasediments. The source of the uranium may lie within the volcanic rocks, possibly related to the liberation of U during devitrification of volcanic glasses (e.g. Rosholt et al., 1971). Locally, the uranium appears to have been remobilized from the volcanics into the overlying pelitic sediments. Within the unwelded tuffs, uranium is concentrated in the coarser grained, more porous zones. Some of the uranium has been remobilized during subsequent deformation and metamorphism of the pelitic rocks. It is possible that some remobilization of uranium has occurred during intrusion of the nearby granites.

Uranium mineralization is present in the Bay du Nord Group elsewhere in the Hermitage Flexure. Approximately 40 km to the west, in the Peter Snout map area, Shell Canada Resources discovered several showings of uranium in the late 1970's. The recorded mineralization occurs in numerous boulders and outcrop of fine grained metasediment and feldspathic schist of the Bay du Nord Group, and also in the Baggs Hill granite, an Ordovician, subvolcanic intrusion (Wells, 1981). Shell Canada Resources has reported up to 30,000 c.p.s. (Urtec UG-130) radioactivity from the Bay du Nord Group in that area. Several samples containing greater than 2,000 g/t U and one sample with greater than 5,000 g/t U have been reported (Wells, 1981). It was thought that the uranium mineralization was related to the intrusion of the Devonian Peter Snout Granite, and that U was remobilized from originally uraniferous sediments by heat associated with that intrusion (Wells, 1981). On the basis of investigations by one of us (S.J. O'Brien), it appears that while the above model may be partially applicable, not all the mineralization at Peter Snout is related to the granite. At least some of the observed mineralization is strata-bound and originally syngenetic, and is concentrated in zones where schistose tuff and pelitic schist are intercalated. It is possible that the granite intrusion results only in minor remobilization. Together with the strata-bound occurrences in the White Bear River area, these showings - regardless of their uncertain origin - serve to further demonstrate the obvious uranium potential of the entire Hermitage Flexure belt.

ACKNOWLEDGEMENTS

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GEOLOGY OF THE BURGEO GRANITE AND ASSOCIATED ROCKS IN THE RAMEA (11P/11) AND LA HUNE (11P/10) MAP AREAS, SOUTHERN NEWFOUNDLAND

by

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ABSTRACT

The La Hune (11P/10) and Ramea (11P/11) map areas are dominated by the Silurian-Devonian Gaultois, Burgeo, North Bay and François granites. A conformable sequence of metasediments and metavolcanics of probable Ordovician age occurs in the Grey River and Devil Bay - Hare Bay areas. Migmatites, metasediments and granitic gneisses occur in the northern part of the La Hune map area mainly as two northwest-trending belts.

The Gaultois Granite is a medium to coarse grained, strongly deformed to locally mylonitic, K-feldspar porphyritic, biotite-rich granite to granodiorite.

The Burgeo granite is an extensive, syntectonic, composite intrusion with a wide variation in textures and mafic mineral content. Generally it is a coarse grained, K-feldspar porphyritic, biotite ± hornblende granite to granodiorite. The Burgeo granite is weakly to moderately deformed but locally it is mylonitic near the contact with metasediments at Grey River and Hare Bay.

The North Bay Granite is a medium grained, massive to weakly foliated, K-feldspar porphyritic, biotite ± muscovite granite, with a U/Pb age date of 396 Ma.

The François granite is a posttectonic granite that intrudes the Gaultois and Burgeo granites. Dikes related to the François granite also intrude the North Bay Granite. The François granite occurs as two overlapping, circular lobes with concentric rings of fine and coarse grained, massive, K-feldspar ± quartz porphyritic, biotite granite which rarely contains muscovite.

Conglomerate, sandstone, shale and limestone nonconformably overlie the François granite near Cape La Hune.

East of Grey River, the Burgeo and Gaultois granites have been thrust southwards on north dipping fault planes. There is no evidence that this thrusting has affected the François granite. West of Grey River the Burgeo granite is extensively sheared in its southern regions, possibly as a result of thrusting. Northwest trending mylonitization occurs along the trace of the Dragon Bay Fault, near Dolland Brook, affecting the Burgeo and Gaultois granites and the migmatites, metasediments and granitic gneiss.

Only the François granite contains significant mineral potential. Some greisen veins were located and minor magnetite probably containing uranium was found in pegmatites. The entire François granite is 2 to 3 times more radioactive than the other granitoids in the area. Extensive silicification of the brecciated Burgeo granite occurs along the Bay de Loup Brook fault and thus may have some gold potential.

INTRODUCTION

The Ramea (11P/11) and La Hune (11P/10) map areas (Figure 1) are located along the south coast of Newfoundland between Burgeo (9 km to the west) and St. Alban's (70 km to the east) (Figure 1). The communities of Grey River, Ramea and François are serviced by coastal boat from Burgeo and Hermitage. Helicopter support is available in St. Alban's and Milltown. Access to the interior is restricted by high coastal cliffs and is best gained by helicopter. Coastal exposure is excellent but high seas often prevent boat work. Inland exposure is excellent and the northern areas were mapped on foot from helicopter-placed fly camps with a base camp in Milltown. The extremely rugged coastal areas were mapped using a helicopter.

This report deals mainly with the Burgeo, North Bay and Gaultois Granites, and Ordovician migmatites in the Hare Bay area; only a brief description of the François granite is given in this report as a detailed description is given in Poole et al. (1985). The metasedimentary and metavolcanic rocks which occur to the east and

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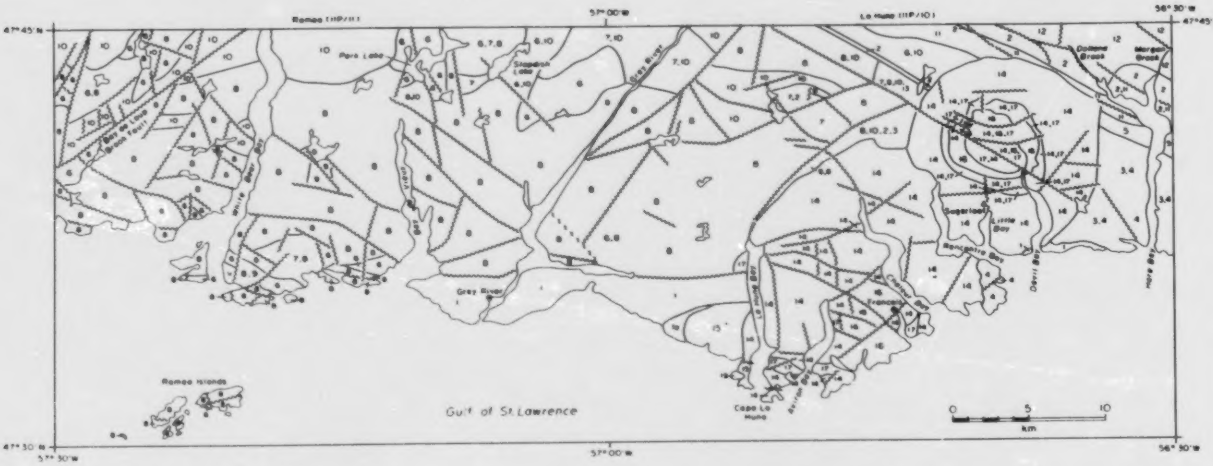

Figure 1: *Geology of the La Hune (11P/10) and Ramea (11P/11) map areas.*

west of the community of Grey River are described in detail by Blackwood (1985).

Prior to 1984, reconnaissance geological mapping was carried out by Buchan's Mining Company (Scott and Conn, 1950), Riley (1959), Williams (1971) and Smyth (1979a,b). A detailed report on the wolframite mineralization at Grey River is given in Higgins (1980). Reconnaissance lake sediment geochemistry was carried out by Butler and Davenport (1978, 1980) and Davenport and Butler (1981, 1982). Detailed follow-up work on rock geochemistry and surficial sediments in the northern part of the François granite are given in McConnell (1984) where a multi-element (U, F, Mo, Zn, Pb) lake sediment anomaly occurs.

An airborne radiometric survey was carried out over the granitoids of the south coast of Newfoundland including the La Hune and Ramea areas (Geological Survey of Canada, 1983a,b) which highlighted the François granite as highly radioactive with only local anomalies in the Burgeo and Gaultois Granites.

REGIONAL SETTING

The La Hune and Ramea map areas cover the southeastern corner of the 3000 km^2 Burgeo granite (informal name), which is dominated by variably deformed biotite granodiorite and granite. The Burgeo granite has intruded Ordovician and presumed Ordovician metasedimentary and metavolcanic rocks, which form a concave belt along the northern margin of the batholith, and an easterly trending belt along the southern margin in the Grey River and Devil Bay areas.

The relative age of the main plutonic units is based on contact relationships and/or degree of deformation. Preliminary U/Pb isotopic work supports the geological interpretation. West of the eastern lobe of the François granite, medium grained equigranular biotite ± muscovite granite dikes from the Burgeo granite cut the Gaultois Granite. Furthermore, the Gaultois Granite is strongly deformed throughout the La Hune map area whereas the Burgeo granite is generally less deformed. This indicates that the Gaultois Granite is the older of the two. The North Bay Granite is only weakly deformed and intrudes a migmatite zone which separates the Burgeo and North Bay Granites. The Burgeo granite and the southwestern part of migmatite zone have been extensively mylonitized along the Dragon Bay Fault zone (Blackwood, 1983) in the Dolland Brook map area (Blackwood, 1984; Dickson and Delaney, 1984) whereas the North Bay Granite is essentially massive in this area and intrudes the migmatites. These relationships have been used by Blackwood (1984) and Dickson and Delaney (1984) to indicate that the North Bay Granite is the younger of the two.

The François granite is the youngest intrusive unit in the map area. It is entirely massive and crosscuts the tectonic fabric in the Gaultois and Burgeo granites. Quartz-feldspar porphyry dikes clearly related to the François granite intrude the North Bay Granite and fine grained dikes of François granite cut the Burgeo and Gaultois Granites.

Ongoing isotopic studies of zircons from the Burgeo granite in the White Bear River area (O'Brien and Tomlin, 1984) indicate an early to mid-Silurian age for this unit. Similarly, an early Devonian age of 396 Ma is indicated for medium to coarse grained, massive to weakly foliated, K-feldspar porphyritic, biotite granite, of

LEGEND

DEVONIAN?

19 *Red and green conglomerate, sandstone, shale and limestone.*

DEVONIAN

Francois granite (Units 14 to 18)

18 *Pink to red, fine grained, massive, equigranular, biotite granite dikes.*

17 *Pink to red, fine grained, massive, quartz-feldspar-biotite porphyritic granite.*

16 *Gray, medium grained, massive, quartz-K-feldspar porphyritic, biotite granodiorite.*

15 *Pink, fine to medium grained, K-feldspar porphyritic, biotite syenite.*

14 *Pink, coarse grained, massive, equigranular to K-feldspar porphyritic, biotite granite.*

DEVONIAN OR OLDER

13 *Gray, fine grained, massive diabase dikes.*

North Bay Granite (Unit 12)

12 *Pink to buff, medium grained, weakly foliated, equigranular to locally K-feldspar porphyritic, biotite ± muscovite granite.*

Burgeo granite (Units 6 to 11)

11 *Pink or buff to locally black, fine to medium grained, very strongly foliated protomylonitic and ultramylonitic, locally K-feldspar porphyritic, biotite granite.*

10 *Buff, medium grained, weakly foliated, equigranular to K-feldspar porphyritic, biotite ± muscovite granite.*

9 *Pink, coarse grained, massive, equigranular, biotite granite.*

8 *Pink to buff, coarse grained, massive to moderately foliated, K-feldspar porphyritic, biotite granite.*

7 *Buff to gray, medium grained, equigranular to locally K-feldspar porphyritic, moderately foliated, biotite granodiorite.*

6 *Buff to gray, coarse grained, K-feldspar porphyritic, moderately foliated, biotite granodiorite.*

Gaultois Granite (Units 3 to 5)

5 *Buff, medium grained, K-feldspar porphyritic, strongly foliated to locally mylonitic, biotite granite and granodiorite.*

4 *Gray to buff, coarse grained, K-feldspar porphyritic, strongly foliated to locally mylonitic, biotite granite.*

3 *Gray, coarse grained, K-feldspar porphyritic, strongly foliated to mylonitic, biotite ± hornblende granodiorite.*

ORDOVICIAN?

2 *Gray to black, biotite ± muscovite psammitic schist, granitoid gneiss and migmatite.*

1 *Undivided psammitic to pelitic biotite schist, migmatitie, amphibolite and various foliated granitoids.* **1a**, *Hornblende metagabbro.*

the North Bay Granite, in the Dolland Brook area (Dickson and Delaney, 1984).

DESCRIPTION OF UNITS

Ordovician Metasediments and Metavolcanics (Unit 1)

An elongate belt of metasedimentary and metavolcanic rocks of presumed Ordovician age (Unit 1) occurs in the Bay de Vieux to La Hune Bay area and continues along the coast to the east of Devil Bay. This unit is described by Blackwood (1985) as a lower sequence of metavolcanics overlain to the south by a sequence of upper greenschist to lower amphibolite facies metasediments and migmatites. This sequence is in fault contact with the Burgeo granite with locally developed mylonite zones. Cordierite porphyroblasts and a hornfels texture are developed close to the contact with the Burgeo granite and indicate a possible intrusive relationship (Blackwood, 1985). The reader is referred to Blackwood (op cit.) for a detailed description of the southern metamorphic unit (Unit 1).

Ordovician Migmatite and Associated Granitoid Gneiss and Metasediments (Unit 2)

Unit 2 has been divided into two subunits. Subunit 2a outcrops in the northeast corner of the La Hune map area as a 1-4 km wide, northwest-trending belt of polydeformed, biotite ± muscovite psammitic migmatite with granitic and migmatitic gneiss which have been intruded by massive, equigranular, biotite-muscovite granite (Unit 12).

Unit 2b forms a 50-100 m wide northwest-trending belt in the north central part of the La Hune map area. It is mainly an equigranular to porphyroclastic, biotite-muscovite granite gneiss with minor convoluted migmatite. Deformation varies from strong to protomylonitic.

In the northwest corner of the La Hune map area, strongly foliated migmatite ocurs as locally abundant large (20 m^2) xenoliths in weakly foliated biotite granodiorite.

Devonian or Older Gaultois Granite (Units 3-5)

The Gaultois Granite outcrops on both sides of Hare Bay and continues along the coast to the mouth of Rencontre Bay. The Gaultois Granite also occurs northwest of the eastern portion of the François Granite. The main component of the Gaultois Granite is an intensely deformed, biotite-rich, K-feldspar porphyritic granitoid. On the coast between Devil Bay and Hare Bay, the Gaultois Granite is in contact with Ordovician metavolcanics (Unit 1) but the nature of the contact is uncertain because of intense deformation.

Unit 3 of the Gaultois Granite is a coarse grained, K-feldspar porphyritic, strongly foliated to protomylonitic, biotite ± hornblende granodiorite. It is bordered on the south by Unit 4, a K-feldspar porphyritic, strongly foliated to mylonitic, biotite granite to granodiorite. Unit 5 is a medium grained, K-feldspar porphyritic, strongly foliated to mylonitic, biotite granite. A 10 m wide dike of massive, metamorphosed, coarse grained equigranular biotite granite of unknown origin cuts the Gaultois Granite east of Hare Bay.

Devonian or Older Burgeo granite (Units 6-11)

The oldest unit of the Burgeo granite is medium to coarse grained, commonly K-feldspar porphyritic, biotite granodiorite (Unit 6). Unit 7 is mainly medium grained, equigranular to locally K-feldspar porphyritic, biotite granodiorite which is commonly spatially associated with Unit 6. Both units are rich in biotite (around 10%) and locally may contain hornblende e.g. near Slopdish Lake (local name). K-feldspar phenocrysts range from 1 to 5 cm in length and may comprise up to 10% of the rock. The granodiorite is cut by dikes of coarse grained porphyritic granite (Unit 8).

Unit 8 is a coarse grained, porphyritic biotite granite with a highly variable proportion of biotite. The majority of this unit is buff with 2 to 5 cm long K-feldspar phenocrysts in an equigranular groundmass with 3 to 5% biotite. Along the coast, west of White Bear Bay, the granite is conspicuously pink to red and generally contains less than 2% biotite. Between Bay de Vieux and White Bear Bay, much of the area is underlain by pink, coarse grained K-feldspar porphyritic granite with less than 2% biotite.

Unit 9 also occurs in this area and is a coarse grained equigranular biotite granite with about 1 to 2% biotite. Dikes of this unit often exceed 50 m in width and have intruded coarse porphyritic biotite granite (Unit 8).

Medium grained, equigranular to K-feldspar porphyritic, biotite ± muscovite granite (Unit 10) underlies the northern parts of the map areas and also commonly occurs as dikes which intrude all other units of the Burgeo granite. Xenoliths of migmatite are locally abundant in this unit. Muscovite forms less than 1% of the rock and is commonly absent. K-feldspar phenocrysts vary in abundance up to 10% and are 1-2 cm in length.

The northeastern part of the Burgeo granite, in the La Hune map area, has been extensively deformed and mylonitized along the trace of a major fault which is a continuation of the Dragon Bay fault zone of Blackwood (1983). This zone of mylonitic granitoids extends from the contact with the mylonitic metasediments of Unit 2 into the Burgeo granite up to 3 km. Coarse and medium grained granites (Units 8 and 10) have been mylonitized and reduced to a very fine grained, K-feldspar porphyroclastic blastomylonite (Unit 11) near the contact with the metasediments. The fabric in the mylonitic and associated strongly deformed granite is defined by flattened quartz and fine grained biotite; feldspar augen up to 2 cm in length are common in the originally coarse porphyritic granites.

Diabase and gabbro xenoliths are common throughout the Burgeo granite and occur mainly in coarse grained, porphyritic biotite granite (Unit 8). Extensive areas of the Ramea Islands are underlain by mafic rocks. The xenoliths range in size from a few centimetres to over 500 m in length. In a few places, swarms of 30 cm long oval xenoliths are cut by thin aplite and pegmatite veins. In other places the more sizeable xenoliths are cut by granite dikes. These mafic xenoliths vary from fine grained diabase to coarse grained gabbro and all have been metamorphosed, with coarse actinolite prominent in the gabbroic xenoliths. The larger diabase and gabbro occurrences are not interpreted to be dikes because of the lack of chilled margins on the diabase. Furthermore, granite dikes cross-cutting the diabase are similar in composition and texture as the host granite.

O'Brien and Tomlin (1984) have interpreted an extensive area of layered peridotite, gabbro and diabase in the Burgeo granite in the White Bear River map area as having an ophiolitic origin. The diabase and gabbroic xenoliths in the Ramea and La Hune map areas have no apparent layering. However, the possibility exists of an ophiolitic source for the xenoliths.

Devonian or Older North Bay Granite (Unit 12)

The North Bay Granite (Unit 12), within the map area, consists of medium grained, equigranular to locally highly K-feldspar porphyritic, weakly foliated, biotite ± muscovite granite locally with large xenoliths (20 m^2) of migmatite derived from Unit 2. The North Bay Granite has intruded the strongly deformed migmatite terrane and clearly postdates the main deformational episodes. Biotite is more abundant than muscovite which may be absent. K-feldspar phenocrysts are locally abundant and are about 2 cm long. The North Bay Granite is cut by a prominent northwest-trending fault but there is little evidence of deformation along the fault.

Devonian or Older Diabase Dikes (Unit 13)

Three southerly-trending diabase dikes were located in the La Hune and Ramea map areas. The dikes are fine grained, equigranular to slightly plagioclase porphyritic. Two dikes are less than 15 cm thick and the other is over 2 m thick. Chilled margins are prominent. No tectonic fabric is apparent in the dikes but the presence of minor epidote and chlorite indicates that the dikes have been metamorphosed in the lower greenschist facies.

Devonian François granite (Units 14-18)

A very brief description of the François granite is given here. For a more extensive description see Poole, Delaney and Dickson (1985).

The François granite is a posttectonic intrusion comprised mainly of coarse grained, porphyritic to equigranular, biotite granite, medium grained, porphyritic biotite granodiorite, fine grained quartz-feldspar-biotite porphyry, medium grained porphyritic biotite syenite and numerous fine grained granite dikes which have intruded the other plutonic units in the La Hune map area and the Dolland Brook map area (Dickson and Delaney, 1984). A 10 m thick north-northeast trending, massive, quality-feldspar porphyry dike has intruded the mylonites and migmatites, north of the François granite and west of Dolland Brook. This dike is a continuation of one mapped by Dickson and Delaney (1984) and thus the dike has a minimum length of 5 km. A conspicuous feature of the northeast part of the François granite is a series of concentric zones of the various units which range in width from 150 m to 2 km. Numerous faults have offset slightly the various concentric rings.

Devonian? Sediments (Unit 19)

A sequence of interbedded, red and green conglomerate with minor sandstone, shale and limestone is located to the southwest of La Hune Bay. This unit nonconformably overlies Unit 7 of the François granite (Blackwood, 1985). Williams (1971) reports that granite boulders occur near the base of this sequence. K/Ar dating of muscovite from this granite gave an age of 399 ± 17 Ma. Williams notes that the granite clasts do not resemble the nearby granites. A more detailed description of this unit is given in Blackwood (1985).

DEFORMATION AND METAMORPHISM

The metasedimentary Units 1 and 2 have been polydeformed. The structure and metamorphism of Unit 1 is described in detail by Blackwood (1985), who describes a generally conformable sequence of metavolcanic and metasedimentary rocks which increase in metamorphic grade from lower amphibolite facies in the north to upper amphibolite facies with associated migmatization in the southern units.

Unit 2 has been polydeformed during two main regional events. The main deformation produced tight isoclinal folds with an axial planar schistosity. This has been recumbently folded with superimposed open, easterly trending, gently plunging folds and locally a steep crenulation cleavage. Metamorphism reached upper amphibolite facies and was accompanied by extensive migmatization.

The mylonitization which has affected the northern margin of the Burgeo granite (Unit 11) extends into Unit 2 but is generally restricted to a narrow marginal zone, probably less than 500 m in width. This has resulted in a strongly schistose rock with a steep, planar, northwest-trending fabric.

Throughout the map area, the Gaultois Granite is very strongly deformed with narrow zones of protomylonite. The granite commonly resembles an augen gneiss as the foliae are completely recrystallized. Near the entrance to Rencontre Bay the Gaultois Granite is extensively mylonitized to a black, very fine grained to glassy rock with 5 mm x 1 mm relict K-feldspar augen.

The Burgeo granite is variably deformed. Near the contact with Unit 1, easterly-trending narrow zones of mylonite (10 m wide) occur in strongly foliated granite. Narrow protomylonite zones occur throughout the coastal parts of the Burgeo granite where the rocks are also extensively faulted and brecciated. On Ramea Islands, the granitoids are strongly deformed to mylonitic and locally the main fabric is cut by a well developed crenulation cleavage. Northeast of the community of Grey River, in the La Hune map area, the granite has been thrust to the south in numerous low angle imbricate thrusts with arcuate fronts bordered by tear faults. The thrusting affects the granite for roughly 10 km to the north of the contact with Unit 1. The effects of this thrusting show a decreasing intensity and increasing dip angle towards the north. This style of deformation continues to the west into the Ramea map area.

The early mafic granitoids of the Burgeo granite are commonly more deformed than the later, less mafic granitoids. This indicates that the Burgeo granite is a syntectonic intrusion with an extensive range in ages of plutonism. An upper limit on the age of deformation in the La Hune - Ramea map areas would be given by dating the François granite which, apart from minor brecciation along faults, is entirely massive. The posttectonic Chetwynd granite, which is lithologically similar to parts of the François granite, has been dated at 372 ± 5 Ma (Anonymous, 1980; O'Brien and Tomlin, 1985), and sets the upper limit for deformation in Burgeo map area.

Along the trace of the Bay de Loup Brook fault the granites are locally mylonitic. The foliation parallels the fault. A subsequent brittle deformation has produced a 100 to 500 m wide breccia zone with 2-10 cm long angular clasts of deformed granite. This breccia has been healed in places by extensive silicification.

MINERALIZATION

The Burgeo granite contains minor occurrences of pyrite. Large diabase xenoliths on Ramea were found to contain disseminated magnetite and tourmaline, and associated brecciated granite contained 1-2 mm thick veinlets of magnetite and tourmaline. Massive granite on Ramea also contained noticeable magnetite. Minor fluorite was found in a granite dike associated with massive quartz cutting diabase, also on Ramea.

The Burgeo granite is extensively brecciated along the Bay de Loup Brook fault. This breccia has subsequently been silicified initially by red jasper-like quartz and subsequently by white to clear vein quartz. This zone of silicification occurs throughout the fault zone and the proportion of quartz varies from 5% to 95%. The fault zone reaches 500 m in width but is generally 100 m wide. Only one minor occurrence of pyrite was discovered and one occurrence of vein calcite was also found. The granite appears highly altered to sericite in a few places. The possibility of gold mineralization exists in this area.

Blackwood (1985) discovered specular hematite along fractures in granite at the entrance to Southeast Arm. Also in the Grey River area there are sizeable subeconomic quartz veins containing wolframite, fluorite, barite and base metals (Higgins, 1980; Higgins and Smyth, 1980; Blackwood, 1985). These quartz veins are posttectonic and cut amphibolite and leucogranite in the Grey River enclave as well as porphyritic granite of the Burgeo granite. Pyrite was located on a joint surface in the North Bay Granite on Morgan Brook.

Lake sediment surveys conducted by Butler and Davenport (1978, 1980) and Davenport and Butler (1982) indicate anomalous W, Mo, Pb and F concentrations in the François granite, particularly in its eastern lobe and the southern part of its western lobe. Anomalous Pb values are found in the vicinity of the Grey River tungsten deposit, and Co, F and Mo are marginally enriched in various parts of the Burgeo granite in the Ramea map area. Airborne radiometric surveys by the Geological Survey of Canada (1983a, 1983b) indicate high U and Th levels in the François granite. A more detailed account of the economic potential of the François granite is given in Poole et al. (1985).

SUMMARY

The oldest units in the La Hune and Ramea map areas are the sequences of probable Ordovician metasediments and metavolcanics that occur in the vicinity of the community of Grey River, along the coast west of Hare Bay, and in the Dolland Brook to Grey River area.

The Gaultois Granite is a medium to coarse grained, strongly deformed to protomylonitic, K-feldspar porphyritic, biotite granite to granodiorite. Dikes of Burgeo and François granite intrude the Gaultois Granite, which is also more intensely deformed than other granitoids in the area, and is thus considered to be the oldest granitoid unit.

The Burgeo granite is mainly a coarse grained, K-feldspar porphyritic, biotite ± hornblende granite to granodiorite. Medium grained biotite ± muscovite granite occurs along the northern parts of the map area and has intruded the coarse grained porphyritic granitoids. The Burgeo granite is weakly to moderately deformed with mylonitic deformation along its northern and southern contacts with the Ordovician units.

The North Bay Granite is a medium grained, massive to weakly foliated, K-feldspar porphyritic, biotite ± muscovite granite which has a U/Pb age date of 396 Ma. It intrudes a belt of migmatites near Dolland Brook.

The Francois granite is characterized by two overlapping circular lobes with concentric rings of fine and coarse grained, massive, leucocratic, K-feldspar ± quartz porphyritic to equigranular, biotite granites which very rarely contain muscovite. The François granite crosscuts the regional fabric in the Burgeo and Gaultois granites and dikes related to the François granite intrude the Gaultois, Burgeo and North Bay granites.

Near Cape La Hune, a Devonian (?) conglomerate sequence with minor layers of sandstone, shale and limestone, nonconformably overlies the François granite.

The Burgeo granite east of Grey River and the Gaultois Granite have been thrust southward on north dipping fault planes whose dip varies from subhorizontal in the south of the Burgeo granite to 45-60° further north and in the Gaultois Granite. The François granite, although locally brittly deformed along faults, does not appear to have been affected by this episode of thrusting. Further west, the Burgeo granite has been extensively sheared possibly in response to thrusting. A northwest-trending zone of mylonitization occurs along the trace of the Dragon Bay fault near Dolland Brook affecting the Burgeo and Gaultois granites and the migmatites, metasediments and granitic gneisses in the area. Extensive brittle deformation is superimposed on a mylonitic deformation along the Bay de Loup Brook Fault.

The François granite contains significant potential for Sn and U mineralization. Greisen veins were located in various parts of the granite and minor magnetite that likely contains uranium occurs in pegmatites near Sugarloaf. The radioactive background for the François granite is 2 to 3 times greater than that of the surrounding granitoids. In the Burgeo granite, extensive silicification occurs along the Bay de Loup Brook Fault and may have gold potential.

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GEOLOGY OF THE FRANÇOIS GRANITE, SOUTH COAST OF NEWFOUNDLAND

by

J.C. Poole*, P.W. Delaney and W.L. Dickson

ABSTRACT

The François granite is a posttectonic composite granite which has intruded the syn- to late tectonic Burgeo and Gaultois granites, their mylonitic equivalents and Ordovician migmatites. Dikes from the François granite have intruded the late tectonic North Bay Granite, a part of which has been dated at 396 Ma.

The Burgeo and Gaultois granites are dominantly coarse grained, K-feldspar porphyritic, variably foliated, biotite granite and granodiorite with extensive areas of younger medium grained biotite ± muscovite granite and granodiorite in the Burgeo granite.

The François granite is composed of two overlapping circular lobes which are composite. The northeastern lobe has a well developed concentric arrangement of intrusive units with a less well developed zonation in the southwestern lobe. The outer ring of the northeastern lobe has intruded the outer part of the southwestern lobe.

Rock types in each lobe are similar with an early outer zone of coarse grained, porphyritic biotite granite intruded successively by medium to locally coarse grained, porphyritic granite, medium grained porphyritic granite and granodiorite, and fine grained equigranular to quartz-feldspar porphyritic biotite granite which is locally granophyric and miarolitic. This sequence forms the rings in the northeastern lobe but generally forms isolated intrusions in the southwestern lobe. West of La Hune Bay, the southwestern lobe contains an area of syenite?, based on its low quartz and high K-feldspar content.

The François granite is distinctly leucocratic with less that 2% biotite and very rarely contains coarse muscovite. The potential for light-ion lithophile element associated mineralization such as tin and uranium is high. Siliceous greisened granite veins are small but locally abundant. Locally, K-feldspar phenocrysts are completely altered to kaolinite? and the entire intrusion is radiometrically anomalous. Minor uranium-bearing magnetite was located in coarse granite pegmatite near Sugarloaf and late magmatic fluorite is common as a coating on quartz phenocrysts. Molybdenite has been reported to occur in an aplite dike in the northern part of the François granite.

INTRODUCTION

Location and Access

The François granite (informal name) is located on the south coast of Newfoundland, approximately 70 km west of St. Albans (Figure 1). The community of François is served by CN Marine coastal boats from Burgeo and Hermitage. The coast in this area is deeply dissected by steep-sided fiords commonly with talus-covered lower slopes. The interior of the François granite, with some considerable effort, can be reached by foot from the head of these fiords but is best reached by helicopter from St. Albans or Milltown, the closest helicopter bases. The northern part of the François granite was traversed by foot but in the southwestern coastal areas the terrain is extremely rugged and sampling by helicopter was carried out. Most of the François granite is virtually devoid of vegetation, soil or till. Only in a few gulleys, where there are thin till deposits, does scrub spruce survive.

Previous Work

Mullins (1958) mapped part of the François granite west of La Hune Bay and described the rock as a porphyritic granite. The François area was mapped on a 1:250,000 scale by Williams (1971) who outlined the massive granitoids and syenite (granite of Mullins, 1958) which now comprise the François granite. Smyth (1979) produced a 1:50,000 scale compilation map of the area with little added detail.

The economic potential of the François granite was clearly indicated by Butler and Davenport (1978) and Davenport and Butler (1981, 1982) using lake sediment geochemical data. These indicated that the François granite contained anomalous U, Mo, F, Pb and W. Further geochemical and geological work by McConnell (1984a,b)

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LEGEND

DEVONIAN

Francois granite (Units 5 to 15)

15 *Pink to red, fine grained, equigranular to slightly porphyritic, massive, biotite aplite dikes.*

14 *Pink, fine to medium grained, quartz and potassium feldspar porphyritic, massive, biotite granite.*

13 *Buff to gray, medium to medium-coarse grained, plagioclase ± potassium feldspar ± quartz porphyritic, massive, biotite granite and granodiorite.*

12 *Pink, fine to coarse grained, potassium feldspar ± quartz porphyritic, massive, biotite granite;* **12a** *– fine grained granite;* **12b** *– coarse grained granite.*

11 *Buff, coarse grained, potassium feldspar porphyritic, biotite granite.*

10 *Pink to buff, coarse grained, quartz rich, potassium feldspar porphyritic, massive, biotite granite.*

9 *Pink, fine to medium grained, quartz-potassium feldspar porphyritic, massive, biotite granite.*

8 *Buff to gray, medium to medium-coarse grained, feldspar ± quartz porphyritic, massive, biotite granite and granodiorite.*

7 *Pink to green, fine to coarse grained, equigranular to feldspar porphyritic, massive, biotite syenite?*

6 *Pink, coarse grained, potassium feldspar porphyritic, biotite granite.*

5 *Pink, coarse grained, equigranular to slightly potassium feldspar porphyritic, massive, biotite granite;* **5a** *– equigranular granite;* **5b** *– slightly porphyritic granite.*

DEVONIAN AND OLDER

4 *North Bay Granite: Buff, medium grained, equigranular to locally potassium feldspar porphyritic, weakly foliated, biotite ± muscovite granite.*

3 *Burgeo granite: Undivided, medium to coarse grained, equigranular to potassium feldspar porphyritic, weakly foliated to strongly mylonitized biotite granite and granodiorite.*

2 *Gaultois Granite: Pink to gray, medium to coarse grained, mainly potassium feldspar porphyritic, strongly foliated to mylonitic, biotite granite and granodiorite.*

ORDOVICIAN

1 *Undivided metasedimentary and metavolcanic rocks including migmatite and minor mylonitic equivalents.*

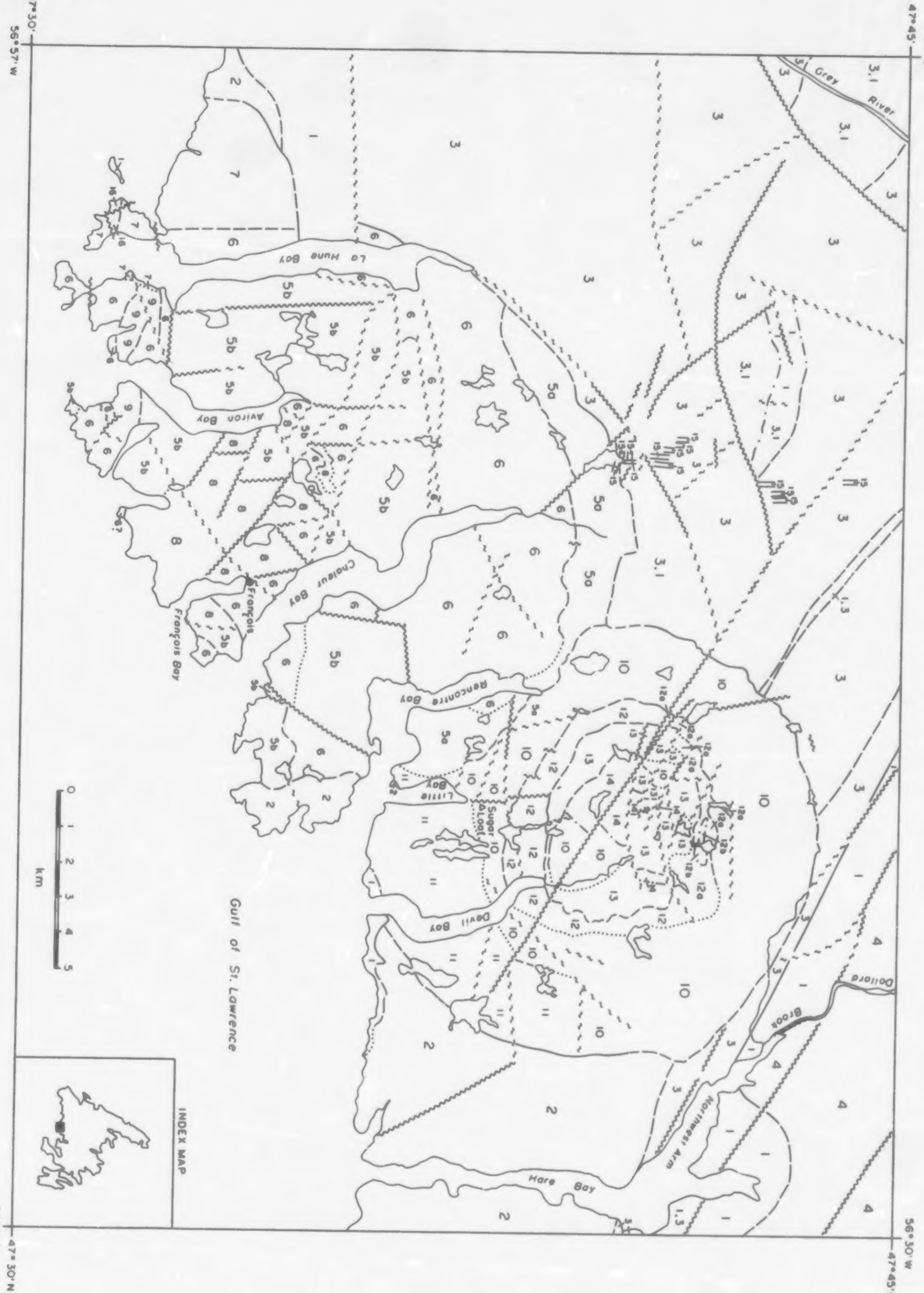

Figure 1: *Geological map of the François Granite.*

indicated anomalous Sn and the rock geochemistry indicated a highly siliceous, light-ion-lithophile (L.I.L.) element-enriched pluton with several varieties of granite and granodiorite. McConnell (1985) has carried out more detailed stream sediment sampling and prospecting in the northern part of the François granite. Airborne radiometric surveys by the Geological Survey of Canada (1983) indicated that the François granite is anomalously radioactive and that there is a zonal arrangement of the anomalies. The syenite of Williams (1971) contained the highest thorium anomaly and the highest U anomalies occur in the vicinity of Sugarloaf, north of Little Bay (Figure 1).

Regional Geology

The oldest rocks in the François area are probable Ordovician, strongly deformed and metamorphosed volcanic and sedimentary rocks (Unit 1) exposed along the coast and in the northern Hare Bay area. These rocks have been intruded by the strongly deformed Gaultois Granite (Unit 2), a medium to coarse grained, porphyritic, biotite granite. The Burgeo granite (Unit 3) is mainly a medium to coarse grained, porphyritic, biotite granite which has intruded the Gaultois Granite and is generally much less deformed than the Gaultois Granite. Thus the Burgeo granite is tentatively considered to be younger than the Gaultois Granite. The North Bay Granite (Unit 4) is mainly a medium grained, equigranular to porphyritic, biotite ± muscovite granite which is only weakly deformed. This granite has a preliminary U/Pb age of 396 Ma (see Dickson et al., 1985). More detailed descriptions of the pre-François units are given in Blackwood (1985) and Dickson et al. (1985).

Mylonitization is locally intense along the contact zones between the Ordovician metamorphic rocks, and the Burgeo and Gaultois Granites. The François granite cross cuts these mylonitic rocks and thus is the youngest intrusive unit in the map area. Posttectonic dikes of Francois granite also intrude the North Bay (Dickson and Delaney, 1984), Burgeo and Gaultois Granites. Contacts between the François granite and the older granitoid units are steeply dipping.

The term François granite (Units 5-14) is an informal name for a variety of massive, pink to gray, medium to coarse grained, porphyritic to equigranular, biotite granitoid phases located in the area between La Hune Bay and Hare Bay. No radiometric age dates are available for the François granite, but the presence of François granite dikes in the weakly deformed North Bay Granite, west of Dolland Brook (Dickson and Delaney, 1984), indicates a maximum age of 396 Ma. The François granite consists of two overlapping circular complexes which trend towards the northeast. In the southwest of the complex, a small area of massive porphyritic syenite is included in the François granite. The two circular bodies which comprise the Francois granite are referred to as the northeast lobe and the southwest lobe. The northeast lobe is considered to be the younger of the two as one unit in the northeast lobe has intruded a unit of the southwest lobe. The relative age of the units within each lobe is known from intrusive relationships but the relative age between units in different lobes is not known.

FRANÇOIS GRANITE

Contact Relationships within the François granite

Contact relationships between each of the units indicate the sequence of intrusion. Unit 6 postdates subunit 5a as Unit 6 becomes finer grained adjacent to the contact and xenoliths of probable subunit 5a were found in Unit 6 within a hundred metres of the contact. Unit 7 postdates Unit 6 along a gradational contact (Blackwood, 1985). Unit 6 and subunit 5b are everywhere in fault contact. Unit 8 postdates subunit 5b with sharp intrusive contacts between finer grained Unit 8 adjacent to coarser grained Unit 5b. In one area the contact dips at 40° to 45° towards the north. The contact relationship between Unit 9 and Unit 6 is not known. Dikes of Unit 9 were found in all units except Unit 7. Thus Unit 9 is probably the youngest unit in the western lobe.

Unit 10 of the northeast lobe clearly postdates subunit 5a of the western lobe. This is indicated by a consistent zone, tens of metres wide, of fine grained, porphyritic granite which becomes coarser grained away from the contact with subunit 5a. The relationship between Unit 10 and Unit 11 is uncertain and may be transitional. The contact between Unit 10 and Unit 12 is often irregular and a sill-like intrusion of Unit 12 is indicated in some localities in the northern portions of the northeast lobe, by vertical textural variations in Unit 12. Unit 13 is a sill-like intrusion into Units 10 and 12, with sharp contacts dipping 40° south in the southern portion of the northeast lobe and 40° to 50° southwest in the southwestern portion of the northeast lobe. Thin, fine grained (chilled), biotite-rich margins occur within Unit 13 at the contacts with Units 10 and 12. Thin veins of Unit 13 intrude Units 10 and 12. Unit 14 probably postdates Unit 13 since fine grained, equigranular aplite dikes, similar to the main body of Unit 14, have intruded Unit 13.

Detailed description of the François granite (Units 5-15)

a. Southwest lobe - Units 5 to 9

Unit 5 is composed of pink, coarse grained, equigranular to slightly potassium feldspar porphyritic, massive, biotite granite, and has been divided into subunit 5a, which forms the northern arcuate margin of the southwestern lobe, and subunit 5b which forms the central part of the lobe. Subunit 5a is in sharp contact with the Burgeo granite and contains locally abundant xenoliths of migmatite and foliated granite close to the contact. The subunit is a homogeneous hypidiomorphic granular granite with approximately 1 to 2% biotite. Steeply dipping, medium grained, equigranular granite dikes have intruded subunit 5a. The dikes are commonly over 50 m in length and 1 m wide. Thin quartz veins are associated with easterly and northerly trending minor shear zones.

Subunit 5b is tentatively correlated with subunit 5a as both have a similar matrix texture, grainsize and mineralogy. However, subunit 5b is generally porphyritic with up to 10%, 1-3 cm long, potassium feldspar phenocrysts. Biotite forms 1% of the rock. The subunit is cut by thin shear zones which contain small barren quartz veins. In a few areas, very thin veins of dark coloured material is probably greisened granite.

Unit 6 is composed of pink, coarse grained, potassium feldspar porphyritic, biotite granite and forms a discontinuous circular zone, which separates subunits 5a and 5b, and forms most of the remaining parts of the outer ring of the southwest lobe. The marginal zones of Unit 6 are generally finer grained than the rest of the unit. Potassium feldspar phenocrysts are 1 to 3 cm in length and comprise 10 to 20% of the rock. The matrix contains varying proportions of potassium feldspar and plagioclase with 1 to 2% biotite. Small, dark, irregularly shaped, metadiorite (?) xenoliths, occur locally.

Unit 7 is composed of pink to green, fine to medium grained, equigranular to feldspar porphyritic, massive, biotite granite and medium to coarse grained, feldspar porphyritic, biotite syenite(?). The coarser grained component of this unit locally contains less than 10% quartz and thus has been termed a syenite, e.g. Williams (1971). Mullins (1958) records that in some areas the finer grained component contains up to 30% fine grained quartz in the matrix. Blackwood (1985) reports that the contact between Units 6 and 7 is gradational. Unit 7 contains 2 to 3 cm long potassium feldspar phenocrysts which form 2 to 20% of the rock and pale green plagioclase phenocrysts, about 1 cm in length are less abundant than the potassium feldspar. Biotite forms 2 to 5% of the rock. Aplite dikes up to 60 cm wide cut Unit 7 in a few places.

Unit 8 is composed of buff to gray, medium to medium-coarse grained, feldspar ± quartz porphyritic, massive, biotite granite and granodiorite. This distinctly more mafic unit is characterized by its generally darker colour and the presence of both plagioclase and potassium feldspar phenocrysts. The phenocrysts are 1 to 3 cm in length and form 10 to 20% of the rock. The matrix contains mainly plagioclase with smaller amounts of quartz and potassium feldspar and approximately 2 to 5% biotite.

Unit 9 is composed of pink, fine to medium grained, quartz - potassium feldspar porphyritic, massive, biotite granite. This unit forms small intrusions and dikes in the southwestern part of the southwest lobe. The granite is generally resistant to weathering and commonly has retained a glacial polish, perhaps as a result of a high quartz content. Potassium feldspar phenocrysts comprise 5 to 15% of the rock and are 5 to 20 mm in length. Quartz phenocrysts are commonly 5-7 mm in diameter and form 2 to 10% of the rock. The matrix contains 1-2 mm crystals of quartz, plagioclase and potassium feldspar with 1 to 3% biotite. Miarolitic cavities are common in this unit particularly near the margins and indicate that the unit was emplaced at a high structural level. Swarms of 10 to 50 cm wide quartz veins are common and cover areas of 3 to 5 m^2.

b. Northeast lobe - Units 10 to 14

Unit 10 is composed of pink to buff, coarse grained, quartz rich, potassium feldspar porphyritic, massive, biotite granite and forms most of the outer ring of the northeast lobe. In the central part of the lobe, similar granite is tentatively correlated with Unit 10. Within a few metres of the contact of Unit 10 with the country rocks, the granite becomes finer grained. Xenoliths of migmatite and foliated granite are common near the margin. Potassium feldspar phenocrysts, 2 to 3 cm in length, make up 5 to 20% of the rock. The matrix consists of quartz, plagioclase, and potassium feldspar, with 1 to 2% biotite. The finer grained varieties of Unit 10 are locally granophyric.

Steeply dipping aplite dikes, 20 to 50 cm wide, and aplite sills are common in the northern part of Unit 10. The dikes appear to have a radial arrangement about the center of the northeastern lobe. The dikes commonly contain a central zone of pegmatite and one sill was found to contain alternating layers of pegmatite and aplite.

Unit 11 is a buff, coarse grained, potassium feldspar porphyritic, biotite granite and forms an arcuate belt along the southeastern margin of the northeast lobe outside of Unit 10. This unit is distinguished in the field from Unit 10 by the buff colour, and higher proportion of plagioclase. Radioactivity is also higher in Unit 11 (see section on mineralization). Unit 11 contains about 10 to 20% potassium feldspar phenocrysts which are 1 to 2 cm in length. The matrix contains about 25% plagioclase with quartz and potassium feldspar and 1 to 3% biotite.

Unit 12 is composed of pink, fine to coarse grained, potassium feldspar ± quartz porphyritic, massive, biotite granite and forms a complete ring in the northeastern lobe. Mappable textural variants of Unit 12 are termed subunits 12a, a fine grained granite, and 12b a coarse grained granite. In general, Unit 12 is highly variable with common changes in grainsize, texture, and proportions of quartz and feldspar phenocrysts. Quartz and potassium feldspar phenocrysts are conspicuous in this unit. Quartz is generally dark gray to brown, subhedral, and 5 to 7 mm in diameter. The potassium feldspar phenocrysts are 1 to 2 cm in length and are locally highly altered to brown kaolinitic aggregates. The matrix of the granite is fine to coarse grained with minor plagioclase and less than 1% biotite.

Unit 13 is composed of buff to gray, medium to medium-coarse grained, plagioclase ± potassium feldspar ± quartz porphyritic, massive biotite granite and granodiorite. This distinctive gray to buff unit is similar to Unit 8 of the western lobe. Contacts are generally sharp and dip approximately 40°S, just north of Sugarloaf.

Unit 13 consists of 10 to 15% plagioclase phenocrysts, approximately 1 cm in length. Potassium feldspar phenocrysts 1 to 2 cm in length occur mainly in the coarser varieties of this unit and may comprise up to 10% of the rock. Phenocrysts of coarse subhedral to anhedral quartz also occur locally and comprise 5% of these rocks. The matrix consists of plagioclase, potassium feldspar, quartz, and 2 to 4% biotite. The proportion of potassium feldspar in the matrix is greater in the coarser varieties of this unit.

Unit 13 has been intruded by steeply dipping, northerly trending aplite dikes, 20-30 cm wide, in the northern portion of the eastern lobe. In one area, northerly trending, 2-4 cm wide greisen veins were observed adjacent to the contact with Unit 14.

Unit 14 is composed of pink, fine to medium grained, quartz and potassium feldspar porphyritic, massive, biotite granite and forms the core of the northeastern lobe. This unit is similar to Unit 12. In Unit 14, quartz phenocrysts are generally black to dark gray, anhedral to subhedral and 0.5 to 0.75 cm in diameter. Potassium feldspar phenocrysts are 1 to 2 cm in length. Combined phenocrysts comprise 10-25% of the rock. The matrix consists of fine to medium grained pink to red potassium feldspar, quartz ± plagioclase and less than 1% biotite.

In the eastern part of this unit the granite grades into a pink, coarse grained, potassium feldspar porphyritic, biotite granite which is tentatively included in Unit 10.

Unit 15 is composed of pink to red, fine grained, equigranular to slightly porphyritic, massive, biotite aplite dikes. To the northwest of the François granite, numerous thick red aplite dikes have intruded the Burgeo granite. The aplite dikes have a consistent northerly trend and are discontinuously exposed for up to 6 km from the edge of the François granite. The dikes range from 5 to 25 m in width and have exposed lengths of over 400 m. Contacts with the country rock are sharp and straight. Near the contact with the François granite, some of the dikes are medium to coarse grained and probably related to Unit 5a of the François granite.

The aplite contains 2 to 5% phenocrysts of feldspar, 2 to 3 mm in length. Biotite occurs as 1 to 2 mm flakes and forms 1% of the mode.

STRUCTURE

The northeastern lobe of the François granite is characterized by major ring structures. The outer margin of the lobe (Units 10 and 11) is 2-4 km wide with a diameter of 11-12 km and has been intruded by an irregular-shaped sill of Unit 12, a 0.5 to 1.25 km wide ring with a 6-7 km diameter. Unit 13 is generally 1-2 km wide but narrows to a true thickness of 60 m (horizontal width of 85 m x sine 45°) at the head of Devil Bay. The unit has a diameter of 4.5 to 5.5 km and has a 45° southward-dipping contact with Unit 12 in the southern and southwestern areas but the attitude of the contact in the north is unknown. The core of the lobe is elliptical and is occupied by Unit 14 in the west which grades into Unit 10 in the east. The elliptical core is 2 km by 4.5 km and at its western margin onlaps Unit 13 in possible lacolith fashion.

The southwestern lobe is not as obviously a ring structure as the northeastern lobe. Unit 5a and Unit 6 form an outer margin in most places. If the lobe was extended into the ocean to complete its circular shape then the youngest units would occur in the center.

Both lobes of the François granite are crosscut by faults. In most cases displacement is difficult to determine. A major northwest trending fault bisects the eastern lobe. Along this fault, the granite is brecciated and in some localities 1-10 m wide zones of 1-5 cm wide quartz veins are parallel to the fault. Displacement at the steeply dipping contact of the eastern lobe with the country rock is less than 200 m indicating a minimal strike slip component. North of this fault, the rings of the northeastern lobe have been offset by numerous faults but the ring structure is still apparent. The southwestern lobe is extensively faulted which may confuse identification of any rings in this lobe.

MINERALIZATION

Lake sediment surveys conducted by Butler and Davenport (1978) and Davenport and Butler (1981, 1982) indicated that the François granite contains anomalous W, Mo, Pb and F concentrations in the northeastern lobe and the southern part of the southwestern lobe. A follow-up stream sediment geochemical survey conducted by McConnell (1984a,b), produced very high Pb and U values as well as moderately high values for Sn, Zn and F, mainly in the vicinity of Sugarloaf. No significant mineralization was found in the François granite and these anomalies may be partly the result of overall large-ion-lithophile enrichment in this highly siliceous granite.

Minor magnetite, probably containing uranium, occurs in pegmatite patches near Sugarloaf. One minor occurrence of possible topaz was located about 4 km north of Little Bay. McConnell (1984a,b) discovered topaz in a scree slope 1 km west of Devil Bay and trace molybdenite in an aplite dike near the northern contact between the François granite and the Burgeo granite. Fluorite occurs in the François granite as a coating on quartz crystals. This was most common in the fine grained version of Unit 12 where fine grained fluorite coats the quartz phenocrysts. This indicates a late magmatic origin for the fluorite and a system enriched in fluorine.

Airborne radiometric surveys by the Geological Survey of Canada (1983a) show the François granite to be enriched in U and Th. The radiometric anomalies were also able to pick out the concentric zones observed in the field. A hand-held GIS-4 Gamma Ray Spectrometer indicated lower anomalous radiometric values than expected but discerned relative differences between units and between the two lobes (Table 1).

SUMMARY AND CONCLUSIONS

The François granite is a Devonian, posttectonic, composite intrusion comprised of two overlapping ring complexes, each

Table 1: *Mean Gamma Radiation for each unit of the François granite. Values obtained using a Scintrex GIS-4 gamma ray spectrometer and reported in counts per second (c.p.s.).*

a. Western Lobe

	Total Counts	K+Th+U	Th+U	Th
Unit 5a	150	6	3	1
5b	260	8	4	2
6	190	7	3	1
7	315	11	6	1
8	190	7	4	2
9	250	9	5	2

b. Eastern Lobe

	Total Counts	K+Th+U	Th+U	Th
Unit 10	290	10	6	2
11	330	12	6	3
12	300	10	6	2
Units 12a,12b	310	11	6	2
13	200	7	5	1
14	310	11	6	2

approximately 12 to 15 km in diameter. The pluton has a northeasterly trend and part of the northeastern ring complex has intruded the southwestern ring complex. The sequence of intrusion in both complexes is similar with early coarse biotite granite intruded by medium grained granodiorite and subsequently by fine to medium grained granite. A small area of syenite at the southwest end of the complex is considered to be part of the François granite. Locally developed miarolitic cavities indicate that the François granite is a high level intrusion.

The ring structure is best developed in the northeastern part of the François granite where four distinctive rings have developed. Airborne radiometric surveys highlight these rings and also indicate that the entire Francois granite is three to five times more radioactive than the surrounding rocks. Highly radioactive magnetite was found in a few pegmatites north of Little Bay. The source of the Pb, Mo, Sn and W anomalies (Butler and Davenport, 1978; 1980; McConnell, 1984) is not apparent. Thin greisen veins are developed locally. Fluorite forms coatings on quartz crystals in a few places in the granite indicating a late magmatic origin for the fluorite and a system enriched in fluorine.

The Francois granite along with the other granites in the area have been geochemically sampled using a 2 km x 2 km grid system. Geologically complex areas were more intensively sampled. These samples will be analysed for major elements and trace elements including Sn, W, U, Mo, Li and Be. Samples have been collected for age dating.

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Newfoundland Mapping Section

ABSTRACT

The Grey River enclave is an east-west trending belt of metamorphic rocks that straddles the Ramea (11P/11) and La Hune (11P/10) map areas; it is bounded to the north and west by the Burgeo granite and to the east-southeast by the Francois granite. Amphibolite facies metamorphism generally increases from north to south in the enclave, culminating in migmatite zones. Felsic metavolcanic and pelitic metasedimentary rocks suggest an affinity with lithologically similar Ordovician rocks found elsewhere along the Hermitage Flexure. Large, pretectonic quartz veins and much smaller, wolframite bearing, posttectonic quartz veins are special features of the Grey River area.

INTRODUCTION

Metamorphic rocks in the Grey River area straddle the Ramea (11P/11) and La Hune (11P/10) map areas on Newfoundland's southwest coast. The study area is located west of Francois and east of Burgeo and Ramea; these three communities, as well as Grey River, are regular stops on CN Marine's south coast ferry run. Burgeo, Ramea and Grey River are serviced by an additional ferry twice a week. A gravel road (route 460) links Burgeo to the Trans Canada Highway near Stephenville.

The present study involved systematic mapping of the metamorphic rocks and adjacent granitoids in the Grey River area on a 1:50,000 scale; it was completed during the 1984 field season. The remainder of the Ramea and La Hune map area was mapped by Dickson et al. (1985) and Poole et al. (1985). Exposure is continuous along the coast and excellent everywhere else in the Grey River area.

The Grey River area was first mapped by the Buchans Mining Company Limited (Bahyrycz, 1957) on a scale of 1 inch to 1320 feet after prospectors discovered quartz veins containing tungsten minerals. This mapping was extended to the La Hune Bay area (Mullins, 1958) and resulted in the definition of most of the major lithologic units, including quartz rich bands described as quartzites. A silica assessment study was done on the quartzites by the Newfoundland Department of Mines, Agriculture and Resources (Fleming, 1967; Bartlett, 1969; Butler and Greene, 1976). The Grey River area was also mapped on a 1 inch to 4 mile scale (Riley, 1959) and 1:250,000 scale (Williams, 1971) by the Geological Survey of Canada as part of the larger Burgeo (11P) map area. Higgins and Smyth (1980) did a regional summary of the area covered by Bahyrycz for the Newfoundland Department of Mines and Energy, partly in conjunction with a Ph.D. study of the tungsten bearing quartz veins by Higgins (1980a,b; Higgins and Kerich, 1982).

GENERAL GEOLOGY

The Grey River area is sited in the south-central part of the Hermitage Flexure (Williams et al., 1970), a generally west trending, sinuous configuration of rock units that occurs in southern Newfoundland. Structural and lithostratigraphic elements have an east-west trend in the map area. The metavolcanic, metasedimentary and migmatitic rocks are here informally referred to as the Grey River enclave and assigned a possible Ordovician age. These rocks are separated from the Ordovician Bay du Nord Group (Cooper, 1954; Chorlton, 1980a,b; Blackwood, 1984) to the north, and the Ordovician Baie d'Espoir Group (Jewell, 1939; Colman-Sadd, 1974, 1976) to the east, by Devonian or earlier granitoids.

Grey River enclave (Units 1-8)

The Grey River enclave is a zone of east-west trending units consisting of metavolcanic, metasedimentary and migmatitic rocks, together with pretectonic rocks of possible intrusive origin (Figure 1). The degree of partial melting and lit-par-lit granitoid veining generally increases from north to south.

Unit 1 is a band of felsic metavolcanic rocks that outcrops between the Gulch Cove area of Southeast Arm and La Hune Bay. A small area of Unit 1 outcrops at the western end of Big Pond, north of Grey River. The main area consists mostly of fine grained, pinkish white to grayish white weathering felsic tuffs with scattered 1 to 3 mm quartz and feldspar phenocrysts. The tuffs are commonly laminated with discontinuous 1 to 5 mm laminae defined by color and compositional variations, and accentuated by thin parallel quartz veins or segregations. Locally, 1 to 25 cm thick beds of felsic tuff contain interlayered 1 to 8 cm thick calcareous beds and lenses (Plate 1). Minor translucent quartz clasts occur in the carbonate; the associated volcanics generally contain a profusion of quartz clasts.

This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

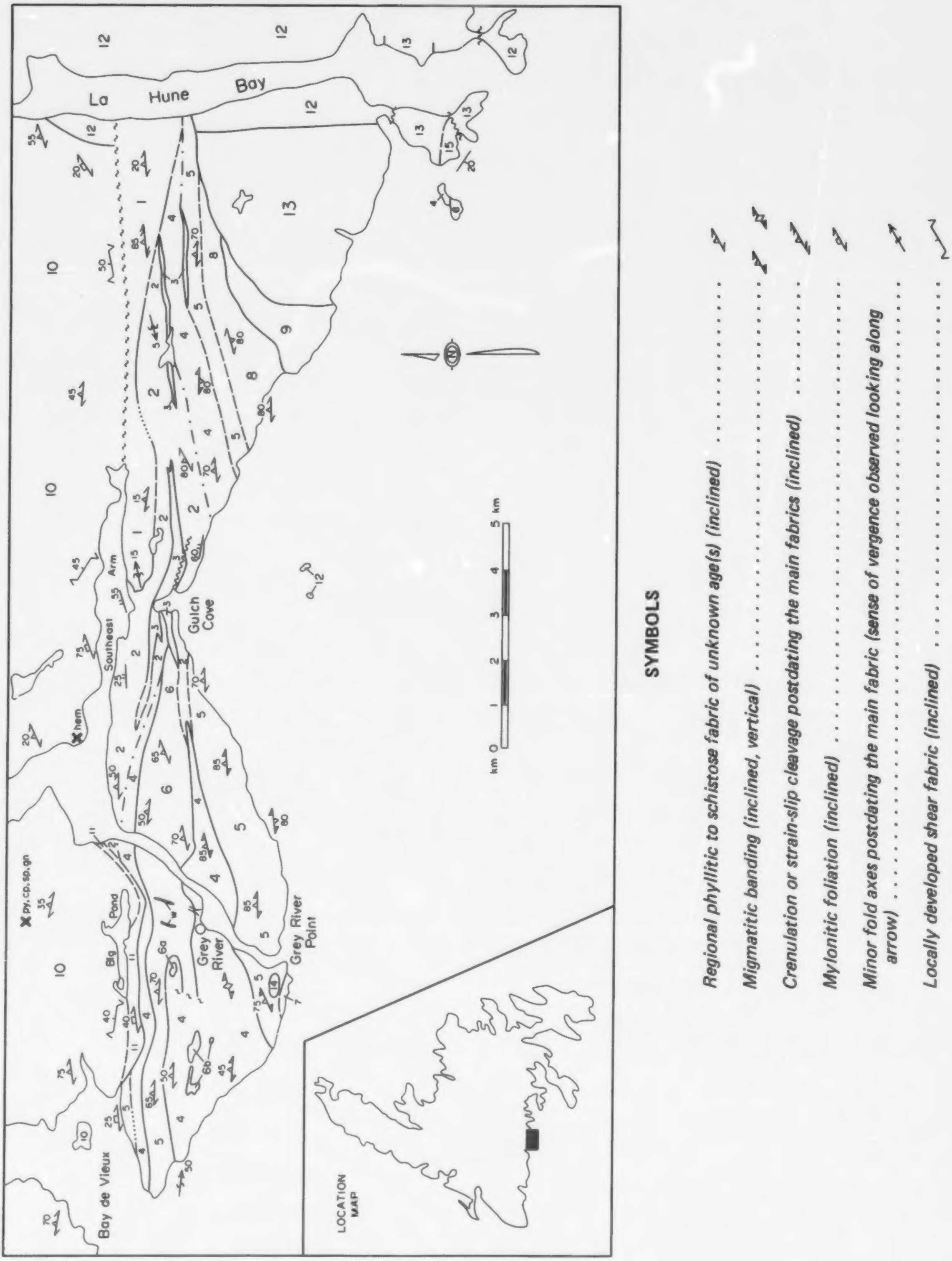
La Hune Bay
Southeast Arm
Gulch Cove
Big Pond
Grey River
Grey River Point
Bay de Vieux
hem
Py, cp, sp, gn
LOCATION MAP
km 0 1 2 3 4 5 km
SYMBOLS
Regional phyllitic to schistose fabric of unknown age(s) (inclined)
Migmatitic banding (inclined, vertical)
Crenulation or strain-slip cleavage postdating the main fabrics (inclined)
Mylonitic foliation (inclined)
Minor fold axes postdating the main fabric (sense of vergence observed looking along arrow)
Locally developed shear fabric (inclined)

Figure 1: *Geology of the Grey River Area, southwest coast of Newfoundland.*

LEGEND

DEVONIAN OR LATER

Posttectonic quartz veins.

15 *Red and green conglomerate, sandstone, shale and limestone.*

DEVONIAN OR EARLIER

14 *Fine to medium grained, minor hornblende and biotite granite.*

FRANCOIS GRANITE (Units 12 and 13)

13 *Fine to medium grained, feldspar porphyritic syenite.*

12 *Coarse grained, feldspar porphyritic, biotite granite.*

BURGEO GRANITE (Units 10 and 11)

11 *Fine to medium grained granite protomylonite, plus minor mylonite and ultramylonite.*

10 *Commonly foliated, medium to coarse grained, feldspar porphyritic, biotite granite.*

9 *Fine to coarse grained hornblende gabbro, including minor hornblendite, diorite and amphibolite.*

ORDOVICIAN (?)

GREY RIVER ENCLAVE (Units 1 – 8)

8 *Agmatite. Hornblende ± biotite schist, migmatite, and amphibolite, intruded by foliated leucogranite.*

7 *Fine to medium grained granite/granodiorite gneiss containing profuse mafic xenoliths.*

6 *Fine to coarse grained amphibolite, including minor gabbro and hornblendite,* **6a**, *peridotite,* **6b**, *hornblendite and gabbro.*

5 *Amphibolite, hornblende ± biotite schist and hornblende diorite migmatite.*

4 *Migmatized semipelitic, pelitic and psammitic schist, plus minor hornblende ± biotite schist.*

3 *Pretectonic quartz veins (?).*

2 *Pelitic to psammitic phyllite and schist, plus minor quartzite, banded amphibolite, and migmatite.*

1 *Fine grained grayish white and pinkish white felsic tuff, locally containing minor carbonate lenses, medium to coarse grained quartz/feldspar lapilli tuff, and minor conglomerate, sandstone and phyllite.*

Locally, narrow zones of green phyllite occur in the volcanics in the Southeast Arm area. An area of enigmatic volcaniclastic rocks occurs in the eastern part of Unit 1 near La Hune Bay. Interpreted as coarse grained lapilli tuff or fine grained agglomerate/conglomerate, these rocks consist of lithic and crystal clasts in a pelitic matrix. The clasts are matrix supported, angular to round and poorly sorted. Pink feldspar clasts are 0.5 to 3 cm long, white feldspar clasts are 2 to 8 mm across and fine grained pink and gray felsic volcanic clasts are up to 7 cm long. The small area tentatively included in Unit 1 north of Grey River at Big Pond appears to be a large inclusion in the Burgeo Granite (Unit 10). It consists of granule to pebble conglomerate containing profuse felsic volcanic clasts, including quartz porphyry and jasper. Brownish red argillite containing grayish white carbonate lenses is associated with the conglomerate. Minor, possibly flow banded, red rhyolite and white weathering felsic tuff as well as greenish gray quartz and feldspar lapilli tuff also occur in the same small area.

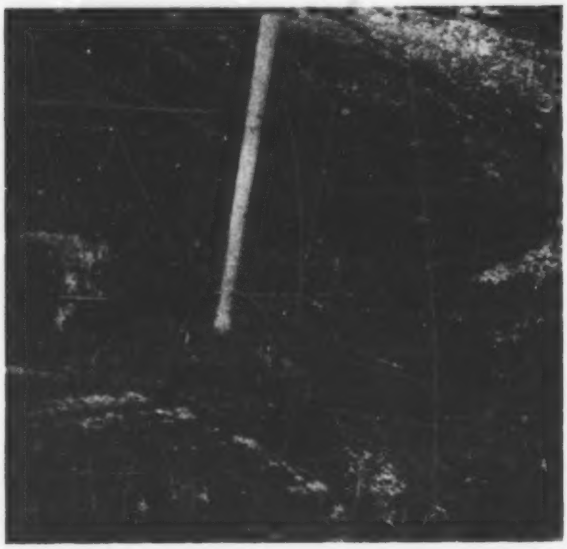

Plate 1: *Felsic tuffs with calcareous interbeds are disposed in a recumbent isoclinal fold. Unit 1 west of La Hune Bay.*

The main regional foliation is penetratively developed throughout Unit 1 and locally is axial planar to isoclinal folds of bedding and laminae. Pretectonic granitoid veins are also folded by this deformation. These early folds are overturned to recumbent (Plate 1) and are commonly overprinted by relatively upright, open to moderately tight folds with a variably developed axial planar crenulation cleavage. The main fabric is a phyllitic foliation in the Southeast Arm and Big Pond areas but fine to coarse grained biotite is developed on fabric planes near La Hune Bay. The volcanics are also recrystallized and contain biotite, muscovite and, locally, hornblende porphyroblasts in the eastern part of the unit.

Unit 2 consists mostly of metasedimentary rocks which occur along Southeast Arm and east of Gulch Cove. It is conformable with, and lies structurally below, Unit 1 felsic volcanics. In the Gulch Cove-Southeast Arm area these rocks are mostly gray or green phyllites and fine grained schists, interlayered with 0.5 to 10 cm wide semipelite, psammite and minor graphitic pelite bands. Locally, concordant, 1 to 8 cm thick, amphibolite layers have gradational boundaries with enclosing psammite, suggesting that originally these were beds of possible mafic to intermediate volcaniclastics. Also, 1 to 2 m zones of chlorite schist, and a more massive dark green rock containing profuse 1 to 4 mm epidote crystals may represent mafic volcanics. Pinkish white weathering felsic tuffs also occur locally in bands up to 60 cm wide and are best developed along the contact with Unit 1. Pink, siliceous lenses, 2 to 10 mm wide, may represent transposed cherty layers in phyllite along Southwest Arm; brownish red carbonate stringers are developed in the same area. Feldspathic quartzite and quartz mica schist occur with banded amphibolite (Plate 2) and pelite in Unit 2 at Gulch Cove.

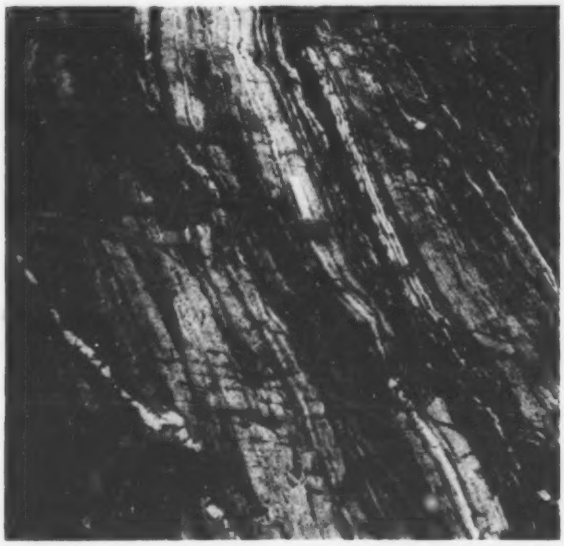

Plate 2: *Primary (?) layering in amphibolite. Unit 2 at Gulch Cove.*

Locally, Unit 2 contains a profusion of 2 to 4 cm wide quartz segregations which, along with 1 to 2 mm granitoid sweats, developed parallel to the main foliation, increase toward the southern contact with Unit 4 migmatite. Also, the quartzofeldspathic component of the semipelite becomes recrystallized into distinct quartz and feldspar crystals with proximity to the southern boundary. Muscovite porphyroblasts, common throughout Unit 2, are well developed in pelitic layers in this area and, along with biotite, are locally preferentially sited in pelitic laminae. Plagioclase porphyroblasts are selectively developed in pelitic layers north and east of Gulch Cove (Plate 3). Concordant, pretectonic amphibolite dikes and granite pegmatite are common in Unit 2 as are boudinaged quartz veins and quartz plus white feldspar granitoid.

Plate 3: *Plagioclase porphyroblasts developed in pelite/semipelite. Unit 2 east of Gulch Cove.*

The main fabric in Unit 2 is co-planar to bedding and locally appears composite where it is manifested as a fine but distinct 0.5 mm banding of alternating quartzofeldspathic layers and biotite rich layers in pelite-semipelite. It also appears to transpose an earlier foliation locally. However, no folding was observed associated with this earlier orientation and it may reflect a mimetically recrystallized primary anisotropy. The main foliation is schistose in the south but phyllitic along Southeast Arm; the presence of concordant granitoid sweats at Gulch Cove, however, suggests that the phyllites represent retrogressed amphibolite facies rocks, possibly due to movement along the faulted northern boundary of the Grey River enclave. Commonly the regional foliation is overprinted by a crenulation cleavage that is axial planar to moderately tight folds. Cordierite porphyroblasts, 1 to 4 cm across, also overprint the main fabric at the entrance to Southwest Arm.

Unit 3, originally mapped as quartzite (Bahyrycz, 1957), is mostly confined to Unit 2 and the main zone occurs in the Gulch Cove area. It forms an approximately 350 m wide zone at the top of the cliff on the east side of Gulch Cove (Plate 4) and has an overall length of 5.8 km. It thins and pinches out in either direction along strike, bifurcating west of Gulch Cove. Other discontinuous, thinner bands occur east of the Gulch Cove zone and on an island in the southeast. Unit 3 consists mostly of white to grayish white weathering, fine to coarse grained quartz. Locally, it is coarsely recrystallized to granular translucent quartz. Minor, but conspicuous, coarse grained muscovite is common. Blebs and stringers of massive to disseminated magnetite, 1 to 6 mm wide and up to 50 mm long, occur locally. Disseminated magnetite is also concentrated in 2 to 20 mm wide parallel bands that are continuous over tens of centimeters but end abruptly, e.g., on the eastern hill overlooking Gulch Cove. Distinct, mostly pink weathering feldspar occurs with the quartz in a number of places in Unit 3, particularly where the main zone tapers off along strike. The feldspars are 1 to 12 mm across and are either spottingly distributed or profuse enough that the rock resembles a leucogranite. This particular observation suggests an intrusive or quartz vein origin for Unit 3 and is consistent with a leucogranite sill interpretation by Higgins and Smyth (1980). Also, discontinuous metasedimentary zones interpreted as rafts or xenoliths are common in Unit 3 and consist mostly of pelitic to psammitic phyllite and schist. Interbedded quartzite, psammite, semipelite and amphibolite, with beds 1 to 10 cm wide, form a concordant zone in Unit 3 on the west side of Gulch Cove. These inclusions range from less than a metre across to several metres wide and tens of metres long. The smaller inclusions look convincingly like xenoliths although it could be argued that the larger ones represent original interbedded material. The main contacts of Unit 3 are generally sharp and abrupt but locally interdigitating occurs and the quartz appears to form tongues that pervade the semipelite and psammite inclusions. Also, small quartz veins which cross-cut beds in Unit 2 adjacent to Unit 3 locally contain minor feldspar and some are texturally identical to quartz in Unit 3.

A pronounced penetrative foliation is developed throughout most of Unit 3. It is commonly resolved as a 1 to 4 mm parting with minor muscovite concentrated on the fabric planes. Locally flecks of magnetite are oriented parallel to the main fabric. The foliation is also more intense along

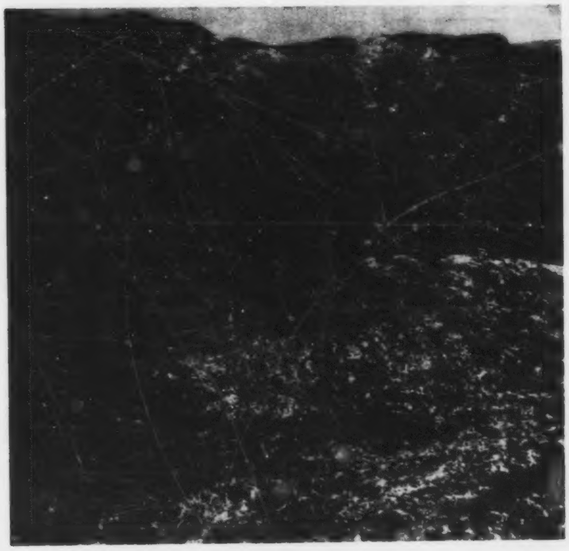

Plate 4: *Looking east from Gulch Cove along the main quartz vein (Unit 3).*

the contact with Unit 2 and appears to be the same regional fabric in both. Minor, open to tight folds of the main fabric in the quartz unit are consistent with the later refolding observed in the metasedimentary rocks. Amphibolite and granite dikes intrude Unit 3 pretectonically in some places.

Unit 4 occurs throughout the enclave, generally structurally below and south of Unit 2. It is a migmatized metasedimentary unit that essentially is the higher grade metamorphic equivalent of Unit 2. Along its northern boundary with Unit 2, a clear gradation between the two units is evident. A crude migmatitic banding is developed in Unit 4, defined by granitoid sweats, lenses of metasedimentary protolith, granite veins and the penetrative foliation (Plate 5). The quartzofeldspathic component of the semipelite protolith becomes recrystallized such that the rock locally resembles a fine grained, strongly foliated, biotite ± minor hornblende granitoid. The discontinuous granitoid sweats are white weathering, wispy and truncated by granite ptygmas. Where the development of migma is greatest, the migmatite is a crudely banded tonalite containing muscovite and biotite rich schlieren. Pelitic portions are locally garnetiferous with some porphyroblasts up to 1 cm across. Plagioclase, muscovite and cordierite porphyroblasts are also developed in pelitic bands within the migmatite. Areas of less migmatized metasedimentary protolith, particularly the more siliceous material, occur throughout Unit 4. One such zone occurs on the coast west of Grey River Point where interbanded psammite and minor quartzite, probably reflecting original bedding, are intruded by lit-par-lit granite veins. Concordant amphibolite bands occur throughout Unit 4 but increase in profusion towards its southern boundary. Some of these are clearly pretectonic dikes but bands marked by gradational boundaries with interlayered pelitic material are interpreted as primary in origin, i.e., mafic tuffs or flows.

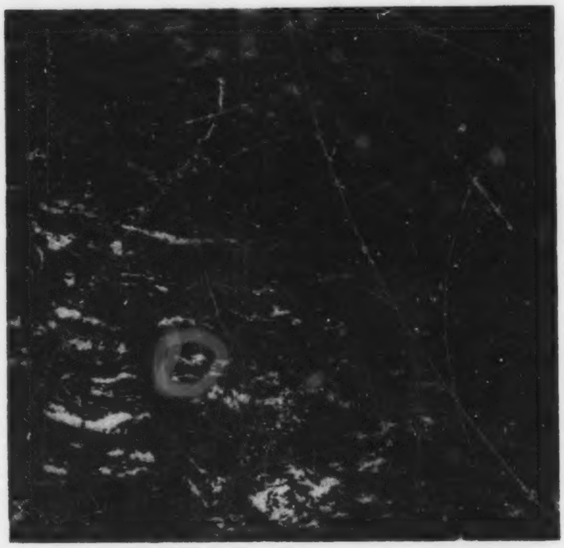

Plate 5: *Quartz/granitoid segregations and veins in migmatite. Unit 4 on shore north of Grey River.*

The regional foliation is strongly developed throughout Unit 4 and most lithological elements in the migmatites are parallel to it. It is overprinted by a crenulation or strain-slip cleavage which is axial planar to moderately tight folds.

Amphibolite and mafic migmatite of Unit 5 form a linear zone south of and structurally below Unit 4; the contact between the two units is concordant and apparently conformable. Unit 5 is narrower east of Gulch Cove where it is limited southward by an agmatite zone. Fine grained banded amphibolite occurs in Unit 5 along its northern boundary where similar amphibolite layers also occur in Unit 4. The banding is interpreted as primary layering and is defined by variations in the color, grain size, and amount of amphibole. In hornblende-poor layers, plagioclase and minor quartz are strongly oriented along the layer parallel foliation. The banding is also accentuated by epidote rich lenses and concordant granite aplite or pegmatite veins. The amphibolites become more coarsely recrystallized and leucocratic to the south, a feature well displayed in the section south of Grey River harbour. The leucocratic component consists of 2 to 6 cm plagioclase porphyroblasts and a profusion of 1 to 8 cm wide segregations of plagioclase plus quartz; these give the mostly dark weathering rock a streaky migmatitic appearance. Cross-cutting veinlets of epidote are also common. Towards Grey River Point, this rock grades into a crudely banded, fine to medium grained, hornblende ± minor biotite, diorite schist or migmatite. It contains 2 to 15 mm wide, hornblende rich lenses and bands as well as local welts of hornblendite several centimeters across. In places, patches of quartz and plagioclase granitoid, 1 to 4 cm across, have diffuse margins with the enclosing hornblende schist or gneiss and are interpreted as *in situ* granitoid sweats (Plate 6). Lit-par-lit granite veins add to the banded migmatitic aspect of Unit 5 in this area. These rocks also grade eastward into less migmatized amphibolite in the area west of Gulch Cove. Hornblende schist and migmatite characterize the unit east of Gulch Cove.

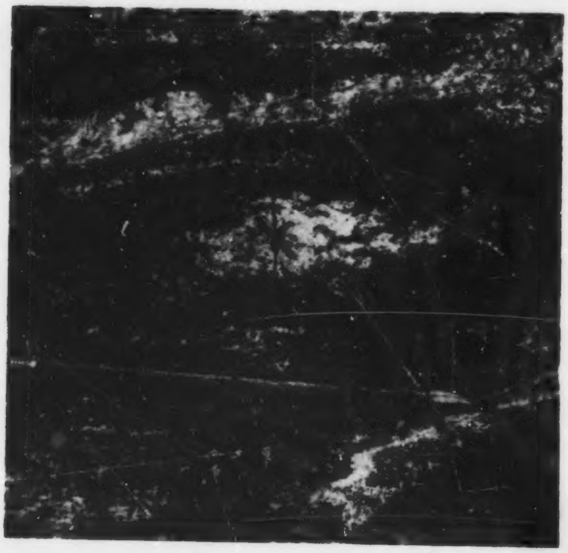

Plate 6: *In Situ granitoid welt of plagioclase and quartz in hornblende schist. Unit 5 north of Grey River Point.*

Unit 5, particularly in an area centered around the entrance to Grey River, is intruded by a profusion of dikes which locally may represent more than 50% of the sea cliff exposures. These include pretectonic, concordant to cross-cutting, amphibolite and granite aplite or pegmatite. The foliated amphibolite dikes generally predate the foliated granite dikes. Posttectonic granitic dikes cut the foliated dikes and are in turn intruded by fine grained, locally porphyritic, diabase dikes. The posttectonic mafic dikes are generally thinner than the early amphibolites and locally form vertical pipes from which many offshoots follow internal contacts and other zones of weakness in the host rock.

A penetrative foliation, parallel to the crude migmatitic banding and well developed layering, occurs throughout Unit 5. It is locally axial planar to isoclinal folds of the banding. Variably oriented, minor shear zones, 1 to 4 cm wide, offset the banding or have the banding rotated into them in some areas. Amphibolite dikes, commonly at a high angle to the crude gneissic banding, have a margin parallel or slightly divergent foliation which locally is axial planar to folds in the adjacent migmatite. Granitoid segregations and quartz veins have developed parallel to the foliation in these dikes which were either intruded into active shear zones (Higgins and Smyth, 1980), or the dikes preferentially sited shearing after intrusion (Plate 7).

Plate 7: *Foliated amphibolite dike truncates banding in mafic migmatite. Note rim of leucogranite of enigmatic origin along the margins of the mafic dike. Unit 5 east of Grey River Point.*

Unit 6 forms a linear zone of amphibolite that is mostly surrounded by Unit 4 in the area west of Gulch Cove. It is generally greenish black weathering, and fine to coarse grained. Plagioclase crystals are 1 to 5 mm across and form augen in the foliation planes. Locally the feldspar exceeds hornblende in zones of leuco-amphibolite; variations in the hornblende/feldspar ratio also produce a crude banding in some areas. The more hornblende rich areas tend to be less well foliated and locally pods of coarse grained, dark green hornblendite occur. Minor biotite was observed in a few places as was fine grained quartz in the groundmass. Locally, along its boundaries, the main amphibolite zone is fine grained with a 0.5 to 30 cm wide banding which appears concordant with the surrounding migmatized metasedimentary rocks. This might suggest a conformable relationship with the enclosing rocks and Unit 6 may have originated as a mafic volcaniclastic or flow. However, away from the margins it resembles a foliated medium grained gabbro including hornblendite pods. The occurrence of small mafic-ultramafic plugs (6a, 6b), here included with Unit 6, further suggests an intrusive origin. Subunit 6a is mostly variably foliated to massive, medium to coarse grained hornblendite, with variable amounts of gabbro. It is quite similar to small hornblendite pods in the main amphibolite zone. Subunit 6b is a coarse grained, relatively unfoliated, ultramafic containing 0.5 to 1 cm pyroxene crystals and minor biotite. Unit 6 is intruded by pretectonic leucogranite veins and both pretectonic and posttectonic mafic dikes; posttectonic quartz veins are common north of Grey River.

The penetrative regional foliation in Unit 6 is locally axial planar to folds of pretectonic dikes and minor banding in the amphibolite. A small zone of intensely foliated, grayish black weathering phyllite on the southeast side of Bay de Vieux contains scattered feldspar and quartz augen and is interpreted as mylonitized amphibolite. Within that zone, medium grained lenses of amphibolite protolith is preserved.

Unit 7 forms a small area west of Grey River Point. It consists of light gray to pinkish gray weathering, fine to medium grained, granite to granodiorite gneiss and migmatite. The banding is defined by discontinuous 1 to 5 mm wide layers, rich in biotite and/or hornblende. Commonly, biotite is the only dark mineral present. The banding or gneissosity either has a regular trend or is quite contorted with a diffuse schlieric outline. Profuse amphibolite lenses in the leucocratic gneiss are oriented parallel to the crude banding. Rarely, pelitic and quartz rich inclusions occur. Some of the amphibolite inclusions must represent mobilized pretectonic dikes since in detail they truncate the schlieric banding and are folded with it. However similar inclusions also truncate oriented mafic lenses that are interpreted as either restite or xenoliths of the hornblende schist/migmatite unit (5) to the north. The leucocratic gneiss is locally concordant with banding in the adjacent more mafic gneiss but locally intrudes and truncates the banding in the latter, e.g., east of Grey River Point (Plate 8). The myriad dikes which intrude Unit 5 also intrude Unit 7.

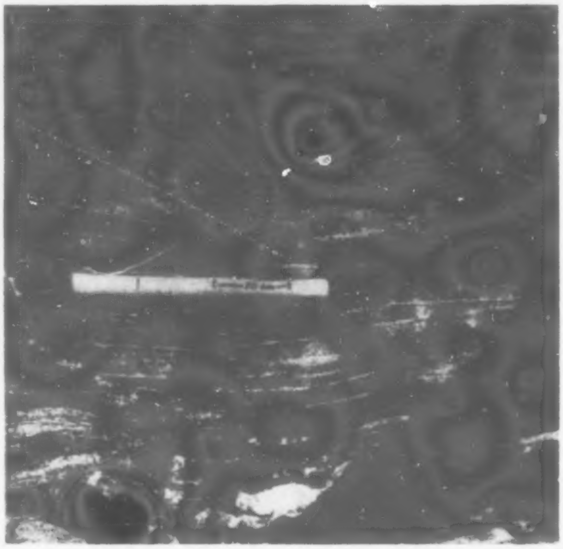

Plate 8: *Granodiorite migmatite (Unit 7) with schlieren structure intrudes regularly banded hornblende migmatite (Unit 5). Unit 5 at eastern entrance to Grey River harbour.*

Unit 8 is an agmatite zone which occurs east of Gulch Cove. Foliated amphibolite and hornblende ± biotite schist and migmatite of Unit 5 are intruded by fine to medium grained quartz and white feldspar granitoid. The intrusion breccia is accentuated by having black weathering, mafic rafts in the white weathering granitoid. Generally the granitoid predominates and locally contains minor biotite. The regional penetrative foliation is common to both rock types.

Gabbro (Unit 9)

Unit 9 is a fine to coarse grained, black weathering gabbro that intrudes the agmatite zone along its northern boundary. The contact is sharp and the gabbro is fine to medium grained along its margin. A moderate foliation is developed in the contact area where Unit 9 is locally amphibolitic. Generally, however, it is massive and where coarse grained, hornblende crystals are up to 1 cm long. Locally, zones of nearly hornblendite composition contain minor plagioclase; rare diorite also occurs in some places. The gabbro is intruded by pink granite aplite dikes.

Burgeo granite (Units 10 and 11)

The Burgeo granite, an informal name used here to replace the Burgeo batholith of Williams (1978), includes a vast area of granitoids to the north and west of the Grey River map area (Dickson et al., 1985; O'Brien and Tomlin, 1985). It intrudes the

Grey River enclave along its northern boundary. Unit 10 is a medium to coarse grained feldspar porphyritic biotite granite. Feldspar phenocrysts are 1 to 5 cm long. A penetrative foliation defined by oriented biotite and minor quartz elongation is commonly developed north of Southwest Arm and in the Bay de Vieux areas; however, local areas of weakly foliated to unfoliated biotite-poor granite also occur. The granite is dominated by cataclastic textures along its contact with the Grey River enclave. Narrow zones of protomylonite to mylonite occur where original feldspar phenocrysts are reduced to pink streaks. Commonly, however, the granite is brecciated or highly fractured, consisting of orange pink feldspar, 0.5 to 3 cm long, in a light to dark green weathering chloritized matrix. The fractures are anastomosing, locally chlorite filled, and cross-cut the penetrative foliation. The contact area west of Southwest Arm locally contains zones of dark gray weathering sheared granite/granodiorite that were originally mapped as metasedimentary rocks (Bahyrycz, 1957).

Unit 11 is a fine to medium grained granite protomylonite containing pink feldspar and minor biotite. It is tentatively included with the Burgeo granite and may represent a contact phase of the larger body. Feldspar porphyroclasts are 1 to 2 mm long and have a pronounced augen structure along with flattened quartz in zones of mylonite. Black weathering flinty zones of ultramylonite occur in some areas along the contact between Units 10 and 11. The protomylonite contains minor amphibolite xenoliths locally.

The relationship between the penetrative foliation in the Burgeo Granite and the main fabric in the Grey River enclave is not clearly understood. They are regionally concordant along part of the contact but the fabric in the granite appears to have a similar attitude to the strain-slip fabric in the metasedimentary rocks along part of Southwest Arm. Also, pelitic rocks at the entrance to Southwest Arm locally have a flinty hornfels texture and large cordierite porphyroblasts that overprint the main foliation. If the porphyroblasts are related to the Burgeo granite, it suggests that the granite in this area postdates the main deformation of the Grey River enclave.

Francois granite (Units 12 and 13)

The Francois granite (Poole et al., 1985) intrudes the Burgeo Granite, the Grey River enclave and Unit 9 gabbro in the eastern part of the map area. Granite similar to Unit 12 occurs on Gulch Cove Islands. The main area of the Francois granite is exposed east of the map area and is described by Poole et al. (1985). Unit 12 is a pink weathering, coarse grained, feldspar porphyritic, biotite granite. The feldspar phenocrysts are 0.5 to 3 cm long and biotite commonly forms 2 to 6 mm phenocrysts. Coarse grained quartz, 2 to 10 mm across, and finer grained white feldspar occur throughout. The granite is texturally uniform and apart from a local fracture cleavage, quite massive.

Unit 13 is a pink weathering, fine to medium grained, feldspar porphyritic, biotite syenite. Minor, fine grained quartz is locally visible in a pink feldspar-rich matrix which contains 0.4 to 2.0 cm long K-feldspar phenocrysts and 1 to 5 mm biotite phenocrysts. White to pale green plagioclase phenocrysts are smaller than the pink feldspar. A feldspar porphyry phase containing minor quartz phenocrysts occurs along the syenite's northern contact. The K-feldspar phenocrysts are commonly zoned and euhedral in the porphyry. Away from the contact, feldspar phenocrysts are profuse to sparsely developed. Locally some biotite is altered to chlorite. Along the eastern contact with Unit 12 granite, a porphyry phase included in Unit 13 contains conspicuous quartz phenocrysts 2 to 8 mm across with square to round cross-sections. The size and number of phenocrysts decrease away from the contact over several metres where it merges with the regular syenite. Unit 13 is unfoliated except for a locally developed contact parallel cleavage along its northern boundary.

Granite (Unit 14)

Unit 14 is a fine to medium grained, pinkish white weathering, granite plug that intrudes Unit 5 of the Grey River enclave on the hill above Grey River Point. It contains minor hornblende and even less biotite; locally pegmatitic patches occur. Completely unfoliated, it is a posttectonic granite of the same age and composition as many of the granite dikes in the same area.

Devonian(?) sedimentary rocks (Unit 15)

A small area of mostly gently dipping, upward facing, sedimentary rocks occurs on the western peninsula at the entrance to La Hune Bay. The most common rock type is pale green to gray weathering and minor reddish brown weathering granule to pebble conglomerate. Generally the conglomerate has a matrix of rounded pink feldspar and quartz granules which supports a variety of pebbles. Minor calcareous patches occur in the matrix locally. The pebbles consist of quartz and/or feldspar porphyry, pink, medium grained granite, flow banded rhyolite, red and purple fine grained felsic volcanics, argillite, sandstone, and quartz. Clasts range from 1.5 to 2.5 cm across. Some of the argillite and felsic volcanic clasts have a parting or cleavage that predated incorporation into the conglomerate. Locally, trough cross-bedding occurs in the conglomerate and where interbedded with sandstone, the conglomerate beds range from 20 [illegible] to 3.5 m thick. The interbedded sandstone and siltstone are reddish brown weathering, fine grained and graded. Commonly calcareous, they grade into white weathering carbonate rich layers containing interconnecting lenses of reddish brown siltstone; in other layers the clastic material d[illegible]ates with anastomosing stringers and pods of carbonate (Plate 9). Interpreted as some type of caliche deposit, these rocks occur along the northern boundary of Unit 15 where it is in contact with the Francois granite (Unit 13).

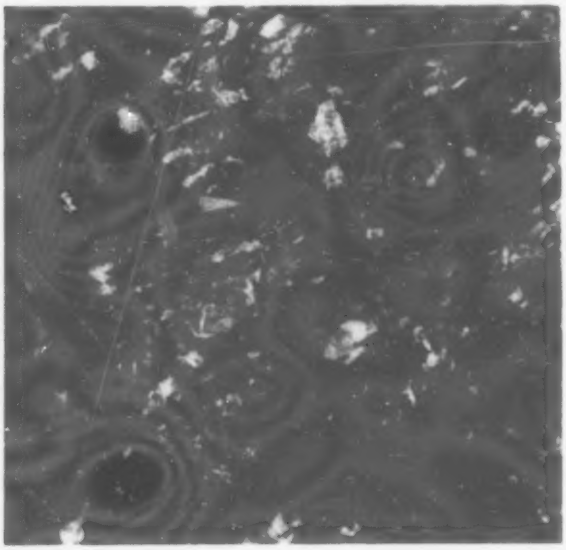

Plate 9: *Carbonate pods in fine grained sandstone. Unit 15 near northern contact with Unit 14, western entrance to La Hune Bay.*

The contact between the sedimentary rocks and the Francois granite was originally interpreted as intrusive (Williams, 1971), but it appears, in fact, to be a nonconformity. The contact is steeply dipping and what appears to be a highly fractured "rubble" zone is developed in the underlying feldspar porphyry of Unit 13. Carbonate fills the fractures in the porphyry which is overlain by calcareous siltstone and sandstone with lenses of carbonate. The caliche-like zone directly overlies this and contains pebbles and boulders (up to 2 m across) of the porphyry; cracks in the boulders are also filled with carbonate. The sedimentary rocks are relatively unmetamorphosed but are overprinted by a slaty cleavage which locally is axial planar to open to moderately tight folds. These rocks are posttectonic with respect to the deformation in the Grey River enclave and may be Devonian or later in age (Williams, 1971).

MINERALIZATION

Most of the known mineralization in the Grey River area occurs in association with posttectonic quartz veins (Bahyrycz, 1957; Higgins, 1980) that are chiefly concentrated in the amphibolite unit (6) north of the town of Grey River. The veins are of variable size, from 2 cm wide veinlets to large 1 m wide veins that are up to 400 m long. Two of the larger veins are shown on Figure 1. The veins follow north to northeast trending faults, joints and fissures that sharply truncate the foliation in the host rocks. Wolframite is the most important tungsten mineral but scheelite also occurs. Other ore minerals include pyrite, chalcopyrite, minor arsenopyrite, molybdenite, sphalerite, galena, bismuth and marcasite. Small, sulphide bearing quartz veins also cut sheared and mylonitized Burgeo granite (Unit 10) to the north, the largest of which on Dog Cove Brook contained pyrite, chalcopyrite, sphalerite and galena (Bahyrycz, 1957). Specular hematite forms thin coatings on fractures in the Burgeo Granite at the entrance to Southwest Arm.

A silica assessment (Bartlett, 1969) on the main quartz zone (Unit 3) east of Gulch Cove proved, by diamond drilling, a total tonnage of 12 million short tons with an average grade of 95.5 percent SiO_2 and 1.9 percent Al_2O_3 (Butler and Greene, 1976). The re-interpretation of the silica deposit as vein quartz could make it a possible target for gold exploration.

Disseminated pyrite mineralization occurs locally in the newly delineated felsic volcanic zone (Unit 1) and in metasedimentary rocks of Unit 2. Felsic volcanic and associated rocks are important hosts for gold and base metal mineralization throughout the Hermitage Flexure and represent the best potential in the Grey River map area.

SUMMARY AND CONCLUSION

Felsic metavolcanic rocks (Unit 1) and pelitic to psammitic metasedimentary rocks (Unit 2) form a conformable sequence in the northern part of the Grey River enclave. The volcanics structurally overlie the metasediments but their stratigraphic relationships are unknown; the presence of thin felsic volcanic bands in the underlying metasediments near the contact might suggest that Unit 1 volcanics are older and grade into Unit 2. Thick quartz rich bands (Unit 3), confined mostly to Unit 2, were previously interpreted as bedded quartzites. However, field relationships suggest that these originated as pretectonic quartz veins, possibly from quartz released from the host rocks during regional metamorphism. The metasedimentary rocks of Unit 2 are progressively metamorphosed southward and form the protolith for a zone of migmatite (Unit 4). Banded amphibolite is concordant with the southern boundary of Unit 4 and grades through a zone (Unit 5) of granitoid segregation and *lit-par-lit* injection to a well banded migmatite at the entrance to Grey River harbour. The protolith for the hornblende migmatite may be mafic volcaniclastics and flows or a mafic intrusion, perhaps similar to the relatively homogeneous zone of amphibolite (Unit 6) that is confined mostly to Unit 4. The mafic migmatite is locally intruded by a granite to granodiorite gneiss or migmatite (Unit 7) which contains profuse mafic inclusions. It is possible that this more leucocratic migmatite originated as an agmatite similar to Unit 8, where a mafic host is pervaded by leucogranite; subsequent or progressive deformation and metamorphism could produce the relationships seen in Unit 7.

Relatively massive gabbro (Unit 9) in the southeast intrudes the Grey River enclave, which is bounded to the north by the Burgeo granite (Units 10 and 11). A regional penetrative foliation in the Burgeo granite locally merges with mylonites in the contact between the granite and metamorphic rocks. Along this contact, the Grey River enclave appears retrogressed as chlorite and sericite phyllites contain remnant quartz and granitoid segregations, typical of the lower to upper amphibolite facies rocks to the south. Thus the final tectonic positioning of the granite postdates the main pulse of metamorphism in the Grey River enclave. However, displacement along the contact was probably not great since original intrusive relationships, indicated by xenoliths and porphyroblasts, are evident in the map area. The posttectonic Francois granite (Units 12 and 13) is mostly massive and truncates the eastward trace of the above units. A small plug of hornblende-biotite granite (Unit 14) is representative of the posttectonic granitoid veining in the migmatite units. Finally, a mostly conglomeratic sequence (Unit 15) was deposited nonconformably upon the Francois granite.

Felsic volcanic rocks occur with mostly pelitic rocks in the Grey River area. This is a common association throughout the Hermitage Flexure, particularly in the Baie d'Espoir and Bay du Nord Groups. The style of deformation and metamorphism (Blackwood, 1984) is also similar; the main period of folding in the Grey River area resulted in isoclinal, possibly recumbent folds, although present attitudes may not reflect the original style. A crenulation cleavage, axial planar to upright, gently plunging folds overprints the earlier structures. Metamorphism increases southward or structurally downward, culminating in migmatites. These observations would tend to suggest that rocks of the Grey River enclave are the equivalent of Ordovician rocks that occur elsewhere along the Hermitage Flexure. A postulated Avalon Zone connection, based on correlating presumed orthoquartzites in the Grey River area with similar rocks elsewhere in the Avalon Zone (Smyth, 1981) is invalid if the present vein quartz interpretation is correct.

ACKNOWLEDGEMENTS

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FOLLOW-UP GEOCHEMISTRY: A DISCUSSION OF FIELD WORK OVER METALLIFEROUS AND MINERALIZED GRANITOID TERRANE IN NEWFOUNDLAND

by

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INTRODUCTION

Field work in 1984 was devoted primarily to concluding a three year study of surficial exploration methods and of the mineral potential of granitoids in south-central Newfoundland. In addition, two small projects unrelated to the granites in Newfoundland were conducted: 1) a pilot study over three areas of gold mineralization to test the effectiveness of lake sediment sampling in gold exploration; 2) an additional 130 lake water samples were collected by M. Batterson in the area of the Strange Lake Zr-Nb-Be-REE deposit in Labrador to further assess the effectiveness of lake water chemistry as an exploration tool. Only work related to the granite project will be discussed here.

Work in 1982 and 1983 had concentrated on anomalous and/or mineralized areas within the North Bay batholith (Silurian) and the Francois and Ackley granites. Areas within the North Bay complex include the Granite Lake area (W-Mo mineralization), the Dolland Brook anomaly (W in lake sediment), the Bottom Brook anomaly (W in lake sediment) and the East Bay anomaly (W-Pb-Mo-Cu-Ag in lake sediment). Areas outside the batholith include the Francois Granite (a Pb-U-Mo-F lake sediment anomaly and a Th-U airborne radiometric anomaly) and the southern margin of the Ackley Granite (Sn-Mo mineralization). The last two granites are Devonian. Results of work in the Ackley, Granite Lake and Francois areas have been released (McConnell, 1984b). In 1984, additional work was done in the Ackley (NTS 1M/10, 11, 14, 15), Francois (11P/10) and Dolland Brook (11P/15) areas, including an additional area described as the Dolland Brook North anomaly (see figure 1). These are discussed below.

Ackley Granite

The highly fractionated southern margin of the Ackley granite is host to stanniferous quartz-topaz-fluorite greisens (± molybdenite) and molybdenite bearing quartz veins (Dickson, 1983 and Tuach, 1984). Most recent exploration attention has focused on the cassiterite mineralization along the Gisborne Lake - Sage Pond granite/volcanic contact. Lithogeochemical data have suggested the potential for additional Sn mineralization along this contact to the west (Davenport et al., 1984). Since conventional soil sampling for Sn has proven effective here (McConnell, 1984), soil and rock sampling was extended in 1984 from Long Harbour west to Rally Pond. As well, 74 reconnaissance stream sediment samples were collected. The granite/volcanic contact is difficult to trace because of considerable overburden and is further complicated by what appears to be roof pendants of volcanics; the latter, however, might prove to be effective structural traps for Sn greisens (Tuach, 1984). No direct evidence of greisens was found to the west of Long Harbour, although quartz veins are common where the contact is exposed.

To the east of Long Harbour, three areas identified as having anomalous Sn values in the previous reconnaissance soil and rock survey were sampled in detail. New occurrences of fluorite and pyrite mineralization in quartz veins were found about 0.5 km north of one of these soil anomalies and several narrow (2-10 cm) greisens and quartz veins were discovered in the vicinity of the rock anomaly.

Francois Granite

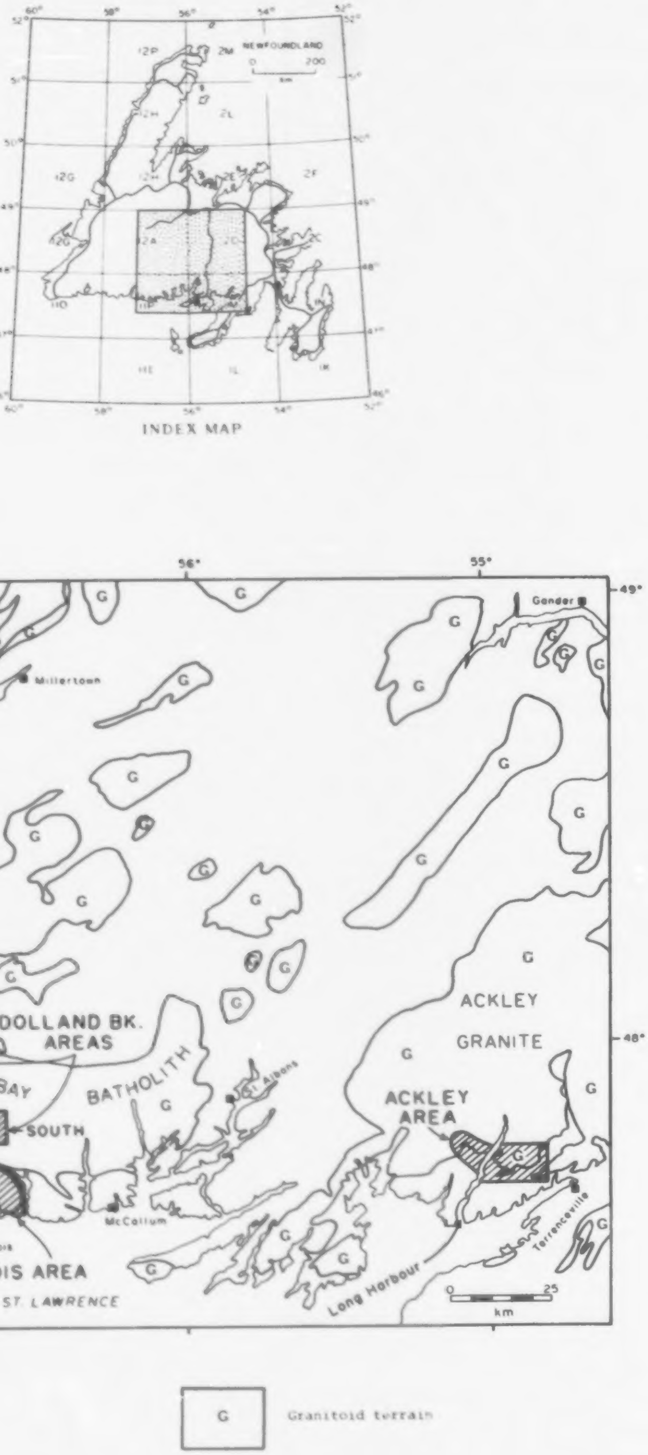
Follow-up work was done at three locations. A major multisample U-Pb-Zn-F anomaly in the reconnaissance stream sediment data was resampled in detail and the surrounding area prospected. Besides the presence of an unusual pitted texture on the weathered surface of the local granite, apparently resulting from preferential weathering of (altered?) feldspars, no field evidence was found to explain the anomaly. Analytical data will become available in 1985.

Work in the second area consisted of detailed stream sediment sampling of two streams in which the previous survey had identified a number of sediments with anomalous Sn values (100 g/t). Again, no mineralization was visible.

Finally, an unsuccessful attempt was made to locate the source of several large crystals of topaz found in a talus slope during the previous survey.

Dolland Brook South Anomaly

Work in this poorly exposed area was continued because of encouraging W values in stream sediments collected during 1983 and the discovery of several scheelite-bearing veins (McConnell, 1984a). Various approaches were made to gain an under-



Locations of 1984 study areas.

standing of the dispersion processes affecting the trace element distribution patterns present in the area. One problem is the presence of high levels of W in many of the stream and lake sediment samples but very low levels in the soils.

Areas within the anomaly were selected for detailed follow-up on the basis of having high W values in stream sediment and/or high residual W values after regression against Fe and Mn. Conventional silt sampling was done in several streams and Fe/Mn nodules and crusts were sampled from some of them. Tungsten concentration has been found to correlate highly with Fe and Mn concentrations in the 1983 stream sediment data.

Overburden drilling was done in two areas in an attempt to penetrate the surface till and to sample either a lower till unit or the till immediately above bedrock. In bogs, the lowermost level of peat was also sampled. Because of the bouldery nature of the till, most holes were unable to penetrate more than 2-3 m with occasional holes reaching 4.5 m. None of the holes was believed to have reached bedrock although it did not appear possible to distinguish bedrock from large boulders. Samples of B horizon soils were also taken to compare with till samples. Despite a mantle of granitic boulders, pebbles of volcanic and metamorphic rocks predominate in the soil and till, suggesting that a major portion of the till itself may be of distant provenance. Thus, the W anomalies in sediments appear to be hydromorphic in origin, with the W being derived either from a deeper concealed till unit of more local origin or from bedrock itself.

The scheelite occurrence discovered in 1983 was examined. Several thin tourmaline-quartz-scheelite veins were found (0.5 to 1 cm wide) and traced with ultraviolet light. It is estimated that the veins carry about 1-3% scheelite in a tourmaline-quartz matrix with accessory pyrite. Exposure is limited to the bottom and sides of the brook.

Dolland Brook North Anomaly

The Dolland Brook North area, located about 10 km north-northwest of the Dolland Brook South anomaly, was selected for preliminary follow-up because of the presence of high W values in the regional lake sediment data (Davenport and Butler, 1982) and because of its proximity to W mineralization to the south-southeast. The area has very little outcrop and considerable till cover. The outcrop seen was mostly feldspar porphyritic leucogranite, generally massive but weakly foliated in places. The till is similar to that in the southern anomaly with a mantle of locally derived boulders over a till of more distant derivation. Stream sediments, nodules and crusts of Mn-Fe oxides, and bedrock were sampled. Evidence of mineralization was found in the form of a small occurrence of pyrite and several nearby quartz veins.

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STRATIGRAPHY AND SEDIMENTOLOGY OF SOME COAL SEAMS IN THE CARBONIFEROUS BAY ST. GEORGE BASIN, SOUTHWESTERN NEWFOUNDLAND

by

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GENERAL INTRODUCTION

This report reflects part of a joint research effort between the Mineral Deposits Section of the Department of Mines and Energy and the Department of Earth Sciences of Memorial University to better assess the fossil fuel potential of the Carboniferous Bay St. George Basin in southwestern Newfoundland. Within this larger framework, the purpose of the particular project reported on here is to better evaluate the economic potential of coals in the basin using modern sedimentological methods and thought.

GEOLOGICAL INTRODUCTION

The Barachois Group is the youngest Carboniferous unit in the Bay St. George Basin of western Newfoundland. Surface sections and a 343 m core drilled as part of this study exhibit medium-coarse grained, cross-stratified, fining-upward, erosively based sandstones interbedded with fine grained, ripple cross laminated and massive sandstones and mudstones. This supports the fluvial origin for the Barachois group suggested by Belt (1968) and Knight (1983).

An uppermost coal-bearing section of the Barachois Group underlies the so-called St. George's Coalfield (Baker, 1927; Bryan, 1938), part of which is shown in Figure 1a. There is another coal-bearing section near Stephenville (Figure 1b) that is also included in the Barachois Group (Knight, 1983). Coal was first cited in the literature in 1822 (Baker, 1927) for this part of Newfoundland, and the St. George's Coalfield has been periodically investigated and its coals mined on a very small scale since that first report.

Hacquebard et al. (1961) have dated the coal-bearing units in the St. George's Coalfield as Westphalian A (equivalent to the Riversdalian strata of Nova Scotia). Miospores recovered from the core drilled through the coal-bearing rocks confirm this age. However, Hacquebard et al. (1961) dated the coal-bearing rocks near Stephenville as Westphalian C/D, indicating a correlation with the Pictou Group of Nova Scotia. This has not been confirmed.

The Barachois Group is estimated to be 1500-1600 m thick in the vicinity of the St. George's Coalfield (Hayes and Johnson, 1938). A thickness of approximately 1500 m was measured by one of the authors (Solomon) in the 1984 field season. Gravity measurements carried out by S. Peavey and H.G. Miller of Memorial University in conjunction with this project put an upper limit of about 2 km depth to pre-Carboniferous basement in the vicinity of the borehole, but this depth ranges up to about 7 km elsewhere in the coalfield.

Previous workers have identified seven coal seams in the St. George's Coalfield. The names, stratigraphic order, thicknesses, along with several proximate analyses are presented in Tables I and II for five of the seams from the area of Barachois Brook (Figure 1a). There are appreciable differences in the thicknesses and descriptions given by the various investigators. These differences are due in part to the variability of the exposures. Many exposures lie along ice-scoured rivers which can modify bedrock exposures. In addition, mining operations have removed much of the easily accessible coal. The report by Bryan (1938) contains several measured sections of the coal seams from working faces in the old mines, and these are probably the most reliable measurements. All the adits and shafts have long since collapsed. Core descriptions are presented in Hayes and Johnson(1938), which indicate the poor continuity of coal seams over short distances, but the descriptions are much too general to be of much use in a sedimentological analysis. More recent works are syntheses of data by Hayes (1949) and Knight (1979, 1983), and detailed mapping along Barachois Brook by Howse and Fleischmann (1982).

The most recent field work (Hyde in 1983, Solomon in 1984) has been directed toward measuring the coal-bearing outcrops and detailed descriptions of sections. In all, eight sections and ten coal seams from seven localities are discussed. Seams are lettered from A to J. We use the term seam loosely because the coals can pinch out over very short distances (tens of metres), and can be more akin to lenses. In effect, as used here, seam is synonymous with occurrence.

Wherever possible, channel samples of the thicker seams were collected, meaning that four or five stratigraphically arranged samples may be present for some of the coal beds. These samples were classi-

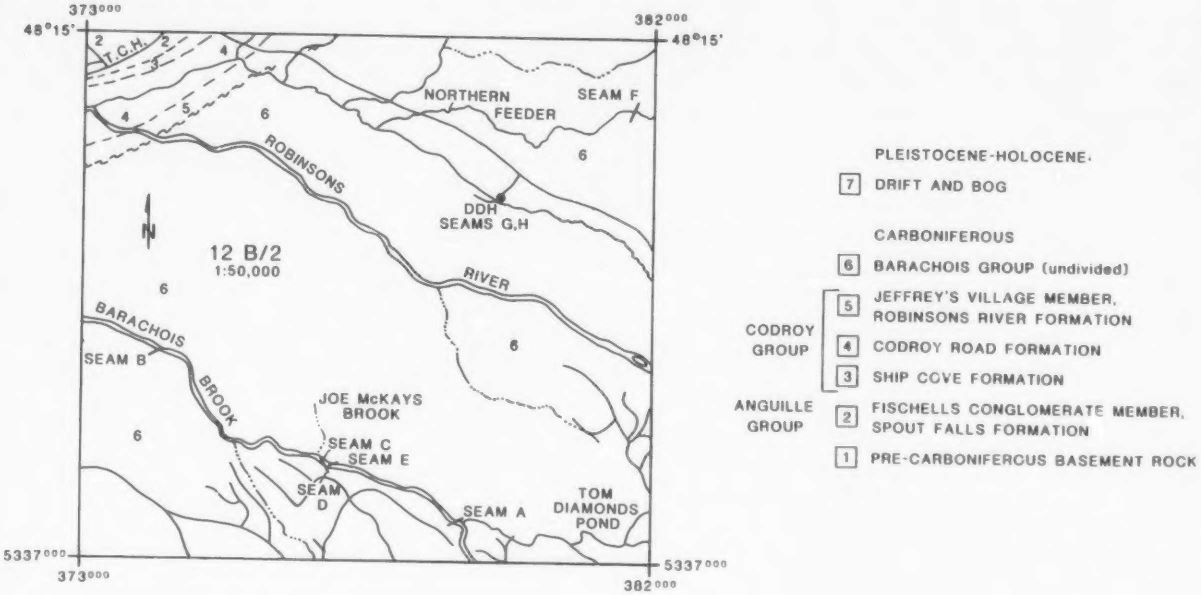

Figure 1a: *Simplified geologic map of Barachois Brook region with seam locations (modified from Knight, 1983).*

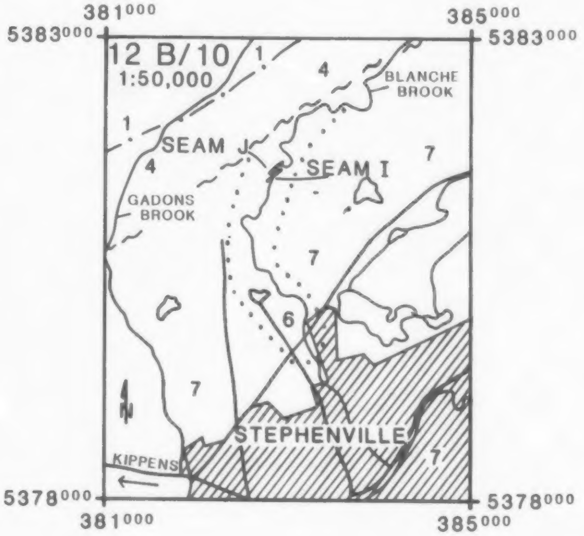

Figure 1b: *Simplified geologic map of Blanche Brook area showing location of coal seams (modified from Knight, 1983).*

fied microscopically (i.e. clarain, durain, etc.) from fresh surfaces. We made no attempt at seam description and classification using polished blocks.

Seam A (Section A)

Located at 789377 within NTS sheet 12B/2 on the north bank of Barachois Brook (Figure 1a), this seam is thought to represent the Tom Diamond Seam (Table I), judging from the maps of Baker (1927) and Bryan (1938). The seam is poorly exposed to the extent that river alluvium had to be scraped away to see it. Earlier workers (Dowling, 1920; Baker, 1927) reported the Tom Diamond Seam to be about a foot (30 cm) in thickness, but this probably included carbonaceous shale, as Hayes and Johnson (1938) and Bryan (1938) report coal thicknesses less than 1.5 inches (3.8 cm).

Seam A consists of thin (millimetre scale) coaly laminations within a 30 cm thick layer of gray claystone (Figure 2). Beneath the claystone occur several metres of gray to brown claystone and siltstone, with the later containing calcareous nodules. A 2 m thick covered zone is directly above the coal. The remainder of the section consists mainly of mudstones (claystones and siltstones) and sandstones arranged in 1.5-2.5 m thick coarsening-upward sequences. A rare, but significant, lithology in this section is an ostracod-bearing micritic limestone.

It was difficult to obtain large samples of the coal, but from smaller fragments it appears to be mostly vitrain that fractures conchoidally.

TABLE I: STRATIGRAPHY AND THICKNESS OF COALS ALONG BARACHOIS BROOK

(measurements in Imperial feet (') and inches (") as per original reports)

Seams	Jukes (?)	Murray (1873)	Howley (1917)	Dowling (1920)	Baker (1928)	Hayes & Johnson (1938)	Bryan (1938)
Cleary	*	1'5"	2'2"	2'	3'	1'8"	1'10"
Jukes	'3	1'3" coal + 2'3" coal & shale	4'8"	2'6"-3'	4'	1'11"+ 5' coal & shale	21" coal+ 5' coal & shale
Furlong (18")	*	*	1'6"	1'6"	1'7"	1'3"	1'1"
Murray	*	*	5'4" sh +coal	4'	"Thick" coal+sh	none visible	4' thins to 0 in fold
Tom Diamond	*	*	*	1'	1'	seams 1.5"	coal 0.5"

TABLE II: ANALYSES OF COALS

	Moisture	Volatiles	Fixed C	Sulfur	Ash	References
Cleary	3.548	30.897	52.229	3.946	6.380	Howley (1899)
Jukes	3.036	30.344	60.142	1.963	4.515	Howley (1899)
Furlong	2.30	31.49	54.21	4.32	14.30?	Bryan (1938)*
Murray	1.96	35.54	54.20	2.8	10.26?	Bryan (1938)*

* These analyses do not add up to 100%

TABLE III: MODAL PERCENTAGES

Seam	L	V	SF	I	S	A	Points Counted
G	0.6 (0.7)*	86.7 (98.7)	0.6 (0.7)	-	7.5	4.6	345
H	0.3 (0.4)	80.9 (97.7)	1.3 (1.6)	0.3 (0.4)	6.8	10.4	309

L-liptinite, V-vitrinite, SF-semifusinite, I-inertinite, S-sulfide, A-ash

* percentages in parentheses are on a mineral-free basis.

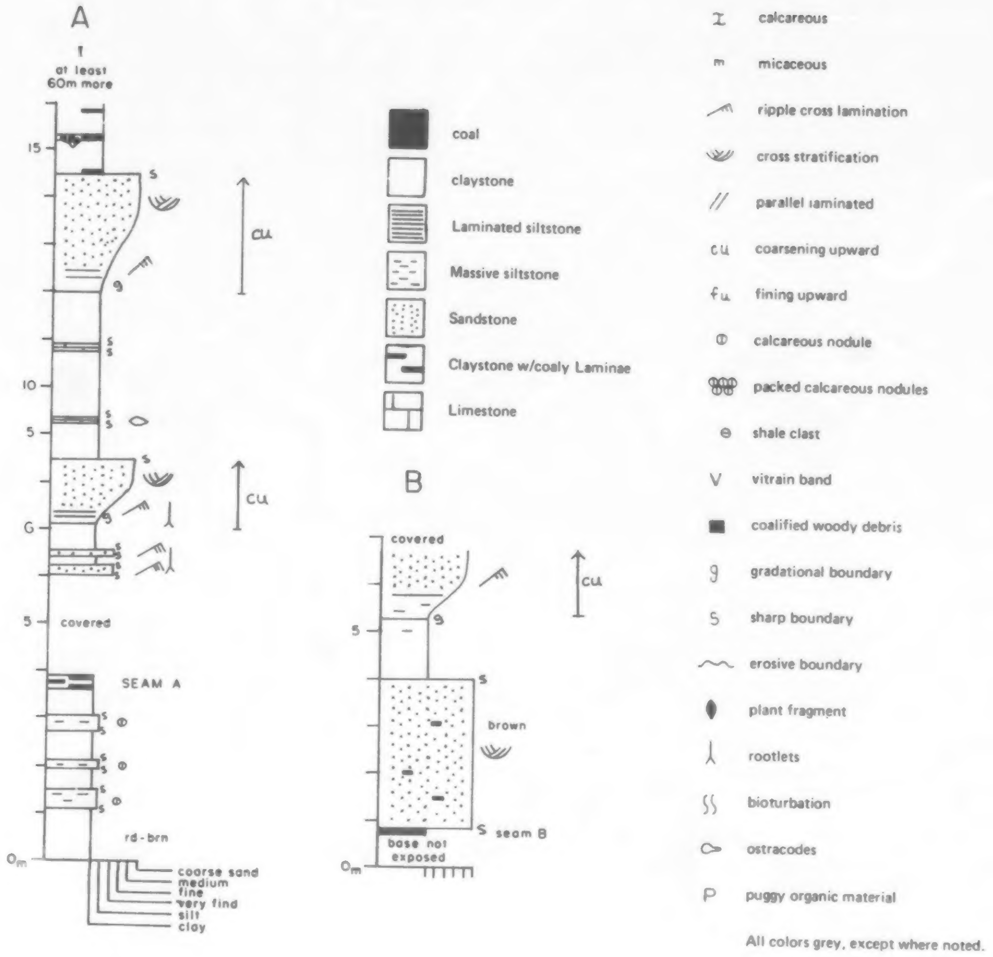

Figure 2: *Measured stratigraphic sections (A and B) containing seams A and B.*

Seam B (Section B)

This seam probably represents what has been termed the Murray Seam (Table I) or Murray No. 1 (Hayes and Johnson, 1938; Hayes, 1949). It is poorly exposed along the south side of Barachois Brook (743403, 12B/2) about 2 m upstream from a small tributary flowing from the south (Figure 1a).

Only about 10 cm of the seam is exposed (Figure 2). The coal appears to be mostly clarain, but with a high ash content (Bryan, 1938, reported 10.26% ash for a grab sample from the Murray Seam, Table II). There also appear to be small lenses of fusain.

This coal seam is sharply overlain by a cross-stratified, coarse sandstone that contains coalified wood debris. This sandstone is overlain by a 1.5 m thick coarsening-upward sequence of gray massive claystone to medium grained ripply cross laminated sandstone.

Seam C (Section C)

Seam C is located on the north side of Barachois Brook about 70 m east of the mouth of Joe McKay's Brook (Figure 1a) at 768387 (NTS sheet 12B/2). The seam is normally submerged in the brook along with much of the section. The seam is composite, consisting of two thin layers (about 12 and 5 cm thick, respectively) of either a dark brown cannel coal or oil shale (Figure 3). The distinction between these two rock types is related to the amount of inorganic material; where inorganic material is a major component, the term oil shale is

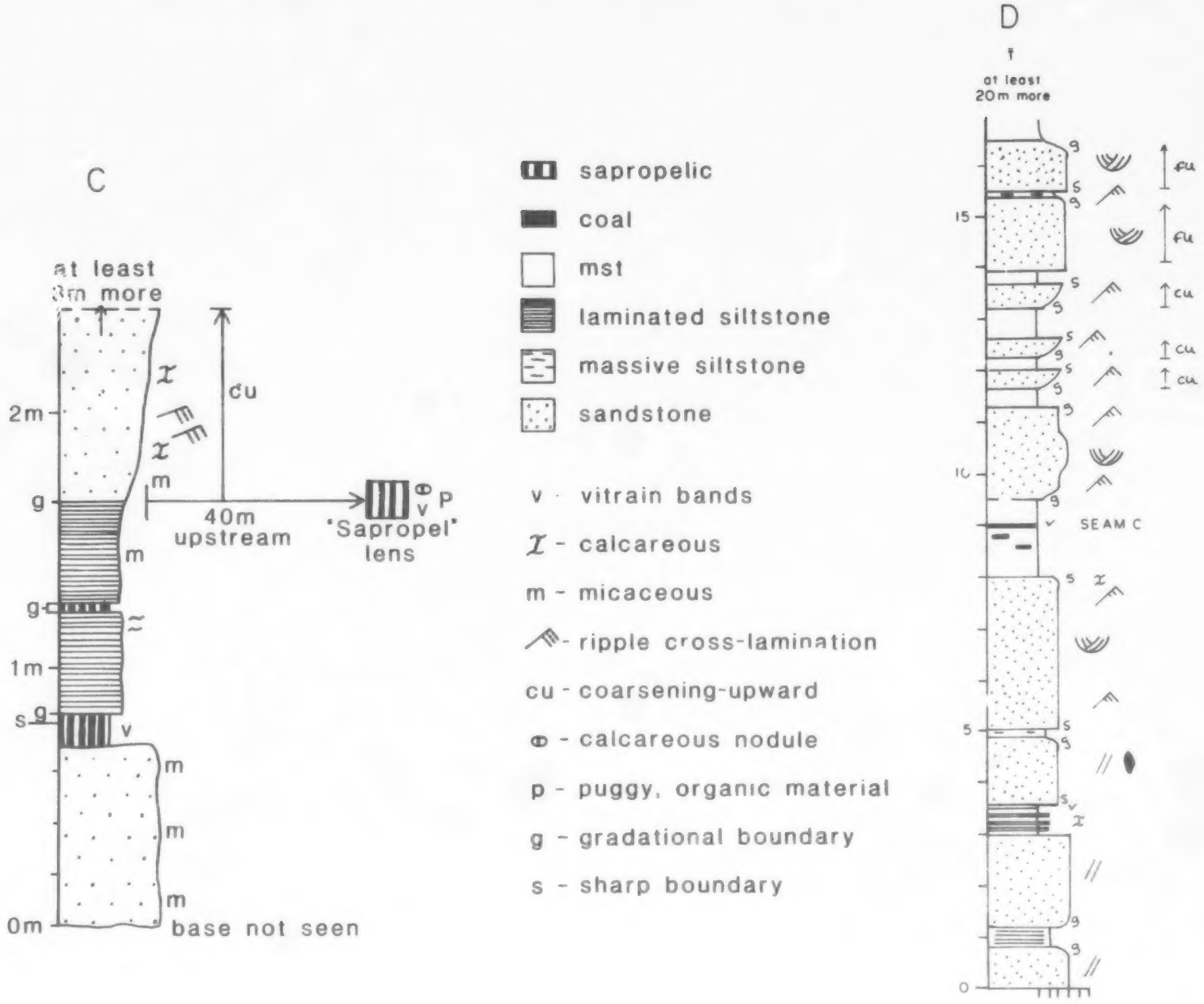

Figure 3: *Measured stratigraphic sections (C and D) containing seams C and D.*

used. A more general term used here in reference to an algal-rich shale is sapropel. Vitrinite bands about 2 cm thick occur within the lower sapropelic layer. Laminated siltstones above the upper sapropelic layer grade upward into a micaceous and calcareous, cross laminated sandstone, thus forming a coarsening-upward sequence.

Another lens of sapropelic material was found 40 m upstream and stratigraphically at the transition between siltstone and sandstone (Figure 3). This lens, which is exposed at low water stage, is believed to be the weathered coal seam reported by Howse and Fleischmann (1982) 110 m upstream of Joe McKay's Brook. This sapropelic material hosts the following: 1) two vitrain layers 1-3 cm thick, 2) soft, puggy organic matter (fusain?) as discontinuous layers (less than 1 cm thick) and thicker lenses (2 cm thick), and 3) black, organic-rich calcareous nodules up to 10 cm in long dimension. Density measurements on samples taken from this sapropelic lens yielded values as low as 1.89 g/cm^3, indicating that the samples are very rich in organic matter.

Although the sapropelic material comprising Seam C is exposed in the general vicinity of the so-called Furlong Bed (Bryan, 1938; Hayes and Johnson, 1938; Hayes, 1949), it very unlikely to be the Furlong Bed because the latter is a humic coal according to the earlier literature and, from the large-scale map in Hayes and Johnson (1938, Plate IV), it clearly outcrops higher in the section than those sapropelic layers.

Seam D (Section D)

This seam is located directly along strike from Seam C (Figure 1a), and outcrops upstream from C, on the south side of Barachois Brook (769386, 12B/2). The exposure is about 10 m upstream from a tributary flowing from the south. Part of Section D, roughly from 7 to 10 m, correlates with Section C.

Seam D consists of thin vitrain bands and coaly stringers within a gray-green mudstone (Figure 4). The mudstone, like that in Section C, grades upward into a sandstone. There are minor vitrain bands lower in the section at 3.5 m. The coaly stringers consist mainly of clarain with an approximately equal number of less than 1 to 2 mm laminations of vitrain and durain.

Seam E (Section E)

This seam is exposed about 8 m above the river on a bluff on the north side of Barachois Brook (Figure 1a) (76953855, 12B/2). It is approximately 50 m upstream from Seam D. Colluvium must be cleared away to see the seam clearly; about 70 cm of coal can be exposed. This is the seam referred to by Howse and Fleischmann (1982) as occurring about 230 m upstream from the mouth of Joe McKay's Brook; it represents either the Jukes or Cleary Seam. The latter possibility is favored since the detailed stratigraphy and thickness of the seam shown in Figure 4 matches closely with the detailed section shown in Bryan (1938, Figure 7) for the Cleary Seam on Barachois Brook. Our mapping also shows the seam to be located at almost the highest stratigraphic level possible; that is, near the axis of a major synclinal fold. This is consistent with the Cleary Seam since it is the stratigraphically highest seam on Barachois Brook. Above the coal, there is a reddish brown sequence that coarsens upward from a mudstone into a cross-stratified sandstone (Figure 4).

The coal consists mostly of clarain and vitrain, with the latter ranging up to 2 cm in thickness. There is one thin shale layer about 1 mm thick near the bottom of the seam. There is also a prominent durain band several millimetres thick at the top of the seam, in addition to some thin pyritic laminations.

Seam F

This seam was located underwater at a bend with a sandy point bar along Northern Feeder at 817442 in sheet 12B/2 (Figure 1a). It is probably what has been called the Shears Seam (Dowling, 1920; Hayes and Johnson, 1938). This seam consists of two coaly layers. The lower layer (F-1) is about 25 cm thick and abundantly pyritiferous. It consists mostly of clarain and, to a lesser extent, vitrain. Durain is minor and occurs mostly near the top and bottom of the layer. Several mudstone bands are also present near the top of the layer. The upper layer (F-2), about 35 cm higher in the section, consists of two vitrain bands (1.5 cm and 0.30 cm respectively).

The strata containing the coal strike at 010° (almost at right angles to the stream course), and dip about 20° to the southeast. The coals are contained in a dark gray mudstone.

Seams G, H (Sections G, H)

These seams are present in the core recovered from the vertical drilling done as part of this study (drill hole located at 796427, 12B/2, Figure 1a). Seam G occurs at 257 m below surface and consists of 2 cm of vitrain. Prominent fissures in the coal are filled with ash. As shown in Figure 4, the coal is overlain by an ostracod-bearing oil shale that coarsens upward into fine sandstones.

The results of a point-counting analysis on crushed and polished samples of Seam G are shown in Table III. These results show that most of the coal is vitrite. There are only two bands thicker than 50 m in the entire crushed sample where liptinite and/or inertinite exceeded the amount of vitrinite. This crushed sample also contained many fragments of carbonaceous shale.

Seam H occurs at 220 m below the surface, and is 10 cm thick. Polished chips of this coal also showed that most of it is also vitrite, but with a high mineral content. As in Seam G, banding is uncommon; where present, it consists of thin bands of semifusinite and/or fusinite. Sporinite is not common, but it is the main liptinitic component; it is disseminated throughout the homogeneous vitrinitic groundmass.

Seam I

Farther north near Stephenville, two seams were located on Blanche Brook (Figure 1b) (12B/10 sheet). The stratigraphically lower coal is termed Seam I; it is about 25 cm thick and is poorly exposed on the eastern side of the brook at the base of a 30 cm high waterfall. This waterfall is located at 8288155 near a prominent sandy area at the side of the brook. The seam was submerged (though the outcrop containing it extends well above water level), but a few samples were collected.

There is much durain and fusain near the bottom of the seam such that fingers smudge quite readily from handling the samples. Higher in the seam, there is more clarain and vitrain.

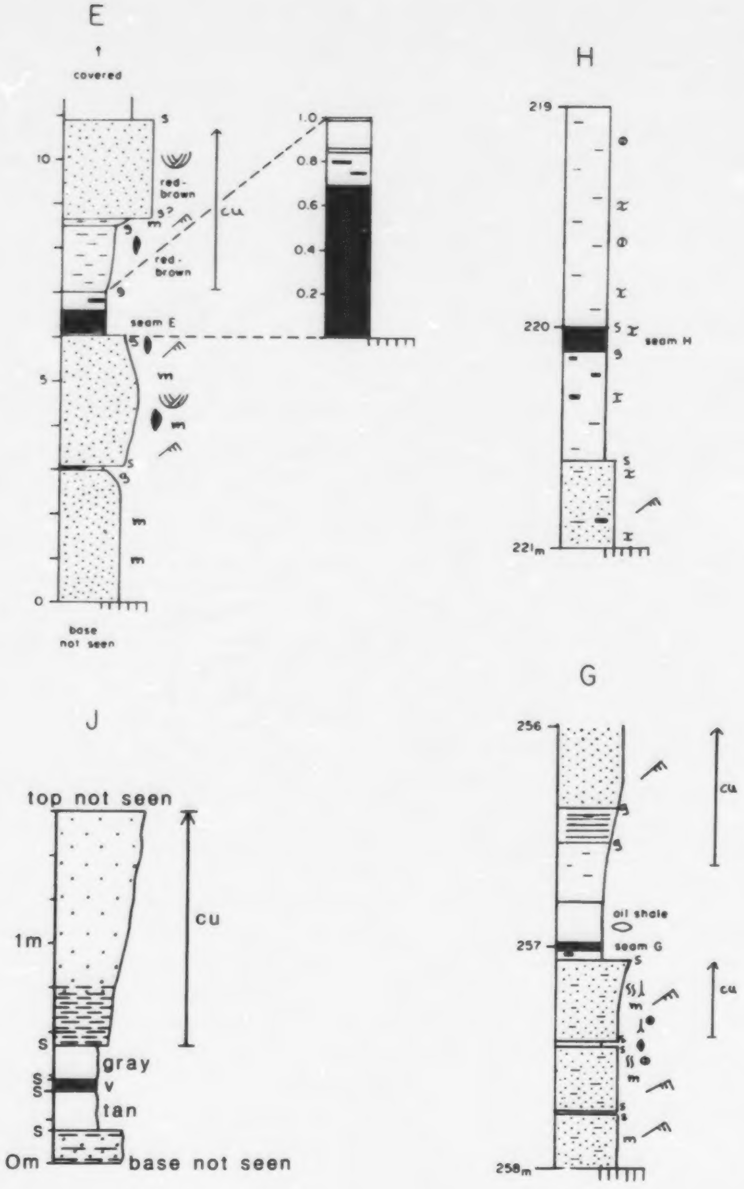

Figure 4: *Measured stratigraphic sections (E, G, H and J) containing seams E, G, H and J. Legend the same as for Sections A-D.*

Seam J (Section J)

Seam J outcrops about 60 m upstream from Seam I and is stratigraphically higher. This seam is about 5 cm thick, and is exposed on a bluff on the western side of the brook. Figure 4 shows a short measured section containing the seam. Above the coal, and succeeding a unit of claystone, is a coarsening-upward sequence ranging from greenish-gray siltstone upward to medium grained sandstone. Fresh surfaces of the coal reveal an interlayering of clarain and vitrain. The coal fractures in a cubic pattern.

F3

DISCUSSION

On the basis of lithological characteristics, biotic elements, and fining-upward sequences, a dominantly fluvial mode of deposition is inferred for the coal-bearing section. The limestones, shales, and oil shales with thin-shelled ostracods and/or molluscs are regarded as freshwater lacustrine deposits, although the fossils require better documentation by specialists. It is within this context that we wish to comment on controls of seam thickness, which have a bearing on exploration decisions and strategies.

One recurring aspect of those portions of the stratigraphic succession close to the seams is the presence of coarsening-upward sequences on a small scale (up to a few metres). In particular, coarsening-upward sequences overlie coal seams in all but two (B and H) of the sections. Small-scale coarsening-upward sequences were clearly shown in the detailed sections of coal seams in the St. George's Coalfield by Bryan (1938). Thus, for these sequences, peat development was followed by deposition of fine grained terrigenous clastic debris.

One way to terminate peat growth is by drowning the bogs by a rise in the water table. This results in the establishment of a shallow pond or lake in which deposition of mud can take place because of enhanced water circulation. Coarsening-upward sequences arise by the formation of minor mouth bars at lake margins where crevasse splay channels terminate (Elliott, 1974; Fielding, 1984). This sequence of events is envisaged for those sections (C,D,G) where lacustrine sediments (in this case oil shales) follow the deposition of peats.

In other sections (e.g., A), coarsening-upward sequences above the coal seams can be explained by deposition of unchannelized lobes of thin crevasse splay sand and mud at crevasse channel terminations. This must be coupled with an approach, either by avulsion or by channel migration, of a main stream channel to account for the coarsening-upward nature of the sequence above the coal. We view the thin sharp-based sandstone units from the 6.0-6.5 m interval in Section A as crevasse splay sandstones. It is not clear if these sandstones were deposited subaerially and directly on top of the peat bog or following submergence of the bog. There is similar ambiguity in other sections (E,J) where evidence for lacustrine versus subaerial deposition is lacking.

We also note that there is only one section (B) in which a seam appears to be partially cut out by an erosively based channel or proximal crevasse splay sandstone. This suggests that the thinness of the Barachois coals is more related to intrinsically unfavorable conditions for the generation of thick peats (related to the position of the paleowater table), than to secondary removal of peat by erosion.

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GEOCHEMICAL FOLLOW-UP SURVEYS, EASTERN NEWFOUNDLAND

by

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Geochemistry-Geophysics Section

INTRODUCTION

Detailed geochemical follow-up was carried out in four areas during the 1984 field season. Two of these areas were in the Avalon Zone (Figure 1), they were (A) Bellevue and (B) Catalina; the other areas were in the Gander Zone, namely (C) Wesleyville and (D) Bay du Nord River. Stream sediment samples were collected in all these areas and in two, Wesleyville and Catalina, detailed soil grids were sampled over areas of interest. In a number of cases rock samples were also collected. All samples were analysed for Cu, Pb, Zn, Co, Ni, Ag, Mn, Fe, Cd and L.O.I. (loss on ignition). The samples from the Bellevue area were also analysed for fluorine. These areas are discussed individually.

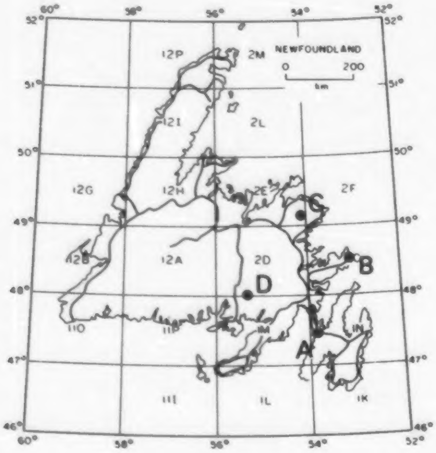

Figure 1: *Index map of survey area, 1984.*

Avalon Zone

Bellevue

A relatively small section in the southern part of N.T.S. map area 1N/2 was not surveyed during a joint Geochemistry - Mineral Deposits Section sampling program conducted in 1983. The sampling of this area (Figure 2), as well as a detailed look in the vicinity of an anomalous Cu stream sediment sample was carried out this season.

The area was mapped geologically by McCartney (1967) and is included in a general review of stratigraphy currently being conducted by King (in prep.). The

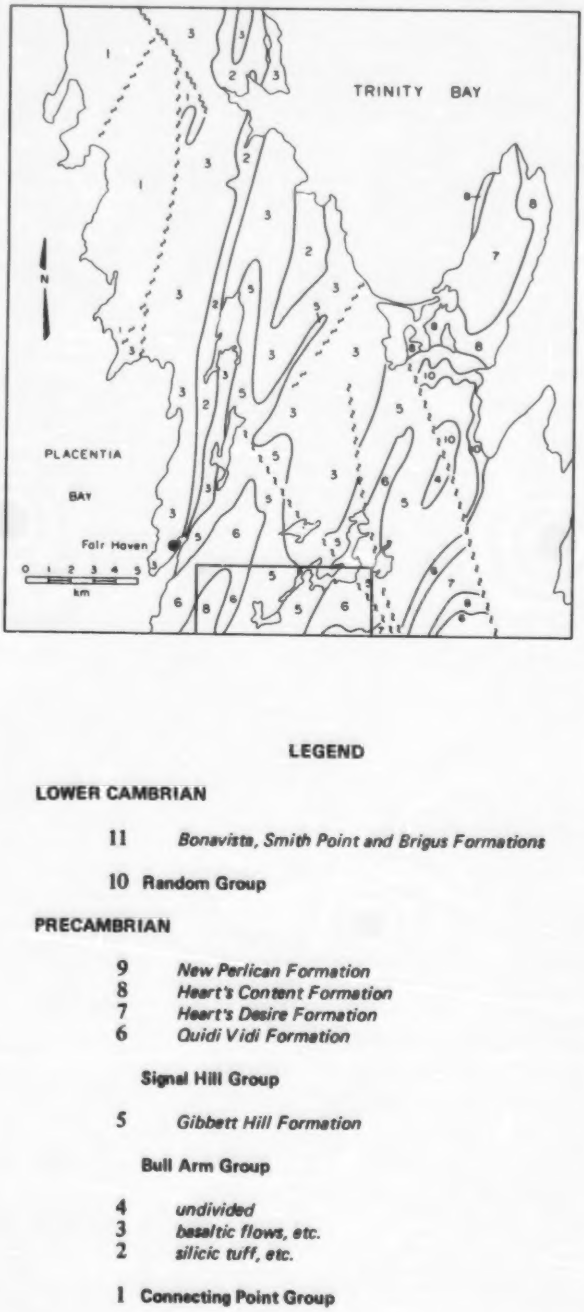

Figure 2: *Simplified geology map of Bellevue showing survey area.*

oldest rocks in the area are a sequence of marine sediments and tuff known as the Connecting Point Group. This group is overlain by a sequence of acid and mafic volcanics of the Bull Arm Group. The immediate study area is underlain predominantly by sedimentary rocks of McCartney's formations of the Musgravetown Group (King's Quidi Vidi Formation).

Stream sediment samples were, as usual, difficult to collect from the area, but samples were collected where possible. In the immediate vicinity of the highly anomalous Cu values (3945 g/t) the stream was resampled at a closer sample interval. The results of these samples indicate that although the values were still anomalous, they were not nearly as high as those collected the previous year. Rock samples were also collected from sites in the immediate vicinity. Visually the only mineralization noted in the area was hematite and pyrite; however, analyses of the rocks have not yet been completed.

All information collected in this area will be released on open file at a later date.

Catalina

Work in the Catalina area (Figure 3) was a detailed study of an area of anomalous Pb values located during the 1983 regional follow-up survey near Bonavista. Stream sediments from the Little Catalina River (unofficial name) indicated anomalous values along most of the length ranging to a maximum of 794 g/t Pb.

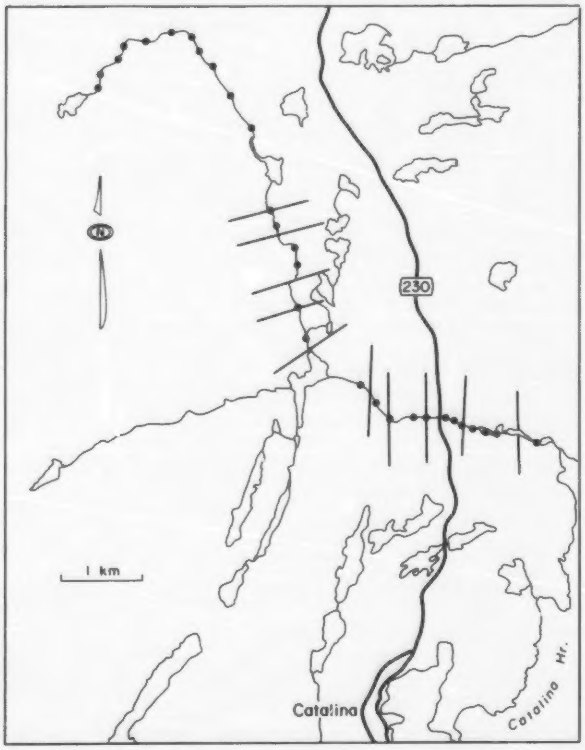

Figure 3: *Little Catalina River area showing stream sediment sample sites and soil grid locations.*

During 1984 the river was resampled at a closer interval, approximately 150 metres. Soil samples were also collected from a grid over the area.

The grid consisted of lines run, generally perpendicular to the stream direction, at an interval of 400 metres on both sides of the stream. Both soil and rock samples were collected.

Mineralization, in the form of pyrite, was found in the stream as float and in outcrop to the east of the Little Catalina River. Samples were collected and submitted for analyses, the results of which are not currently available. A known lead occurrence on the coast just south of the community of Little Catalina was visited. The mineralization consists of fracture filling of the sedimentary rocks with crystalline quartz with pods of galena crystals. Fractures with quartz filling were noted over several hundreds of metres, but galena appeared limited to a narrow zone a few tens of metres wide. The widest vein observed was less than 5 cm and appeared to pinch out over a distance of about a metre.

Data from the present study is being compiled and will be released on open file when completed.

Gander Zone

Wesleyville

The survey in the Wesleyville area (Figure 4) complements the 1983 survey (Butler and Davenport, 1984). The area surveyed is located in the vicinity of Alleys Pond. A zinc anomaly was recorded in the regional lake sediment survey (Butler and Davenport, 1984) and regression done on data from the area confirmed the anomaly.

Stream sediment samples were collected from all streams which flow into or out of Alleys Pond. The Zn anomaly was centred on a small lake to the south of Alleys Pond. The soil sample grid was established using the long axis of the lake as a baseline. Cross lines were run in a generally east-west direction and varied in length from 400-800 metres.

When all the data has been compiled, an open file release will be made which includes all geochemical, geophysical and Quaternary data collected in the area.

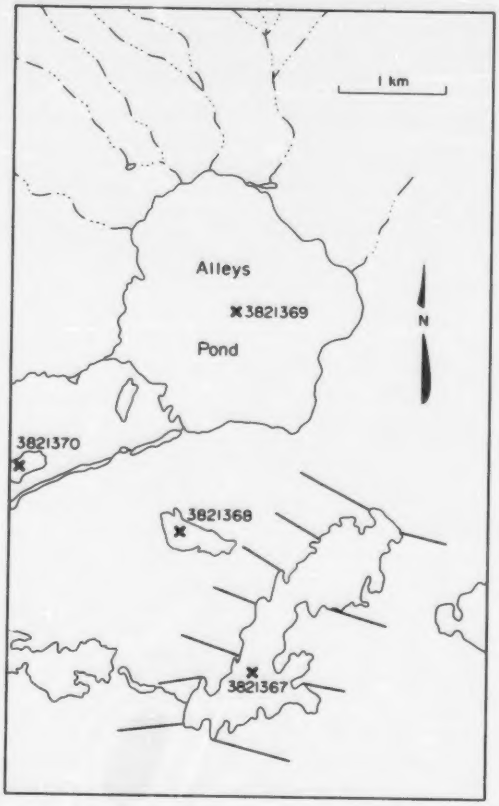

Figure 4: *Soil sampling grid - Alleys Pond area.*

Kim Lake

Kim Lake (Figure 5) is the unofficial name of a small lake immediately north of Medonnegonix Lake on the Bay du Nord River. The area is 18 km east of the Baie d'Espoir Highway and 36 km northeast of Milltown.

During field work in the mid 1950's (Berrange & McCabe, 1955), employees of Newfoundland and Labrador Corporation Limited (NALCO) located a mineral showing which they called Upper North Bay River Showing (later Kim Lake Prospect No. 1). The showing was a "good sulphide showing" to quote Berrange (1955) and further exploration work was recommended because of the "favourable geological setting" and because "although outcrop is very scarce a good sulphide showing has been found".

The following year the area was surveyed in more detail by NALCO employees. The area of the showing was examined, trenched and 30,000 feet of line were cut and soil sampled at 100 foot intervals on the baseline and crosslines. As a result of the trenching the shear zone was traced to the eastern side of the brook for a distance of 120 feet, but sample results were less encouraging than the original showing.

Swinden (1980), in his economic geology study of the eastern Hermitage Flexure, states that the showing is in pelite schists of the Isle Galet Formation, is of limited extent and has no economic importance.

In 1977-1978 the Geochemistry Section of the Mineral Development Division conducted a regional lake sediment sampling survey which covered a part of the area each year (open files Nfld. [986] and Nfld. [1002]). Evaluation of the results of these studies showed that to the west of Kim Lake was an area anomalous in Zn and, to a lesser extent, in Pb.

A detailed stream sediment sampling program was conducted in the area using two sampling teams. All streams in the vicinity of the anomalous lakes were sampled at as regular a sampling interval as possible. The sampled area was extended beyond the Bay du Nord River to include the galena showing on that river. In all, 68 stream sediment samples were collected from the area. These samples will be analyzed for the usual elements and gold analyses will be done. Some rock samples were also collected from the mineralized zone on the Bay du Nord River.

When the analyses and statistics are completed, the data will be released as an open file.

ACKNOWLEDGEMENTS

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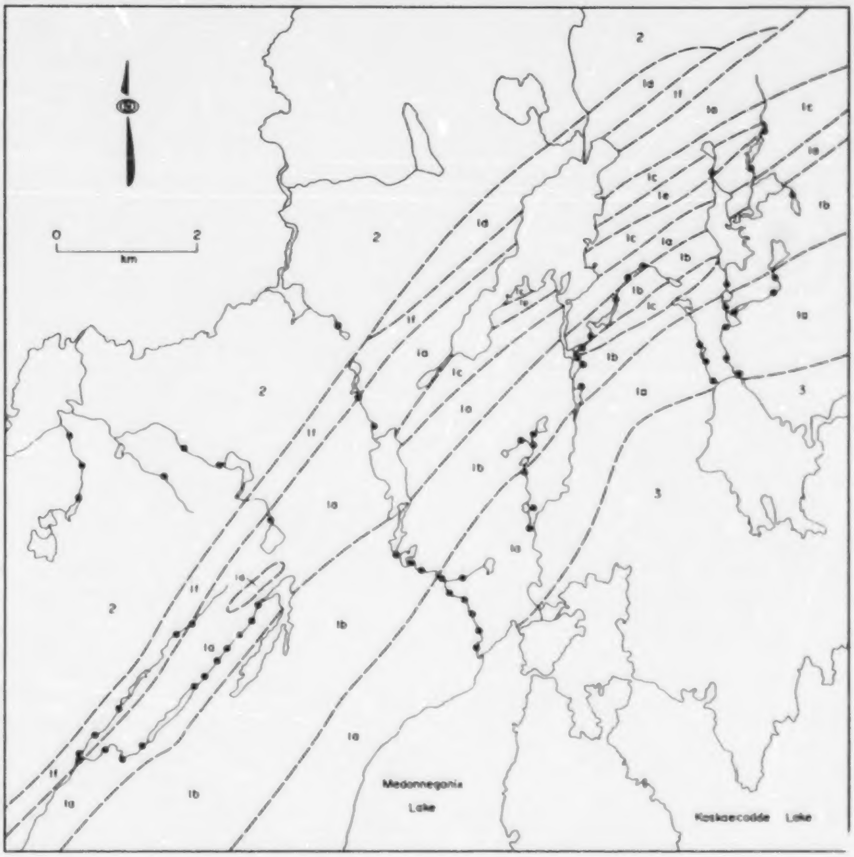

LEGEND

DEVONIAN OR YOUNGER

3 *Granitoid intrusive rocks*

ORDOVICIAN

2 **BAIE D' ESPOIR GROUP;** *chloritic and graphitic schist, felsic tuff, and micaceous greywacke*

1 **ISLE GALET FORMATION**

(a) grey to black argillite, minor psammite, mafic to felsic tuff

(b) green chloritic schist and pelite

(c) massive amphibolite, pillow lavas

(d) conglomerate, quartz pebble conglomerate

(e) red to purple mudstone

(f) chloritized, medium grained, equigranular granite

Source of Geological Information

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Figure 5: *General geology of the Bay du Nord River area showing stream sediment sample locations.*

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AURIFEROUS SPECULARITE-ALUNITE-PYROPHYLLITE DEPOSITS OF THE HICKEY'S POND AREA, NORTHERN BURIN PENINSULA, NEWFOUNDLAND

by

Allan Huard and Cyril O'Driscoll

INTRODUCTION

Location and Access

This study is being conducted on an 8 x 18 km belt of volcanic and intrusive rocks centered 20 km south southwest of Swift Current. This area lies between the western shore of Placentia Bay and the Burin Highway (Figure 1) . It is cut by Sandy Harbour River, Paradise River and the Monkstown Road. This road provides a good section through all the major rock types and good access to the southern part of the study area. The northern part was studied from a camp on Hickey's Pond which is 9 km from the Burin Highway, and connected by a trail suitable for all terrain vehicles.

Previous Work

The area was previously included in 1:250,000 mapping by Anderson (1965) and 1:50,000 mapping by O'Driscoll and Hussey (1978) and O'Driscoll (1978).

The specularite showing at Hickey's Pond was examined in terms of its potential as a source of iron in the 1930's (Dahl, 1934; Bainbridge, 1934). Howland (1938, 1940), in a study which dismissed the deposits' iron potential, noted the presence of alunite $(KAl_3\ (SO_4)_2(OH)_6)$ and remarked on the mineralogical curiosity of its occurrence with specularite. Hussey (1978a,b), with the aid of X-ray diffraction analyses, showed that the "alunite" was actually the Na-rich analogue, natroalunite. He also recognized pyrophyllite as an important constituent at Hickey's Pond and in the surrounding altered rocks. He also suggested that the area may have economic potential in terms of precious metals. Hussey (1978b) discussed a paper by Knight (1977) which reviewed the various modes of occurrence of alunite and its association with various types of ore deposits. The deposits mentioned by Hussey (1978b) include porphyry copper deposits, gold alunite veins, recent hot spring activity, and hydrothermal gold-silver-copper ores associated with caldera collapse structures. In 1982 Selco staked the area in the immediate vicinity of Hickey's Pond. The discovery, in 1983, of a quartz-specularite-alunite-lazulite body, 13 km southwest of Hickey's Pond, (Tuach, 1984) renewed interest in the area and prompted the initiation of this study. APEX Limited staked that showing in the fall of 1983. O'Driscoll (1984), in following up Husseys's suggestion of precious metal potential, demonstrated anomalous gold values in rocks collected by Hussey in the Hickey's Pond area. Seven rocks were analyzed for gold; the highest concentration being 850 mg/t, in a banded rock containing specularite, natroalunite, quartz, pyrophyllite and sericite.

Present Investigation

The present study is intended to: (1) locate other specularite-pyrophyllite-alunite occurrences in the area; (2) study any alteration assemblages associated with these occurrences; (3) analyze the occurrences and different alteration assemblages for gold content; and (4) describe the location of the showings in terms of their stratigraphic level, relation to structures, intrusions or any other feature which could aid in their systematic location.

Physiography

The area is typically flat to gently rolling but rises rapidly to the White Hills in the extreme northern part. Outcrop is abundant except in low-lying swamp areas and in the few wooded regions. In general, stereoscopic examinations of air photos enables very small lineaments to be traced.

GENERAL GEOLOGY

All the alteration assemblages observed are in volcanic rocks of the Late Precambrian Love Cove Group (Figure 1). Isoclinal folding and flattening of the volcanics prevents recognition of facing criteria and estimation of stratigraphic thicknesses. However, metamorphism is slight, with alteration of mafic minerals to chlorite and some alteration of feldspars the only results. Mafic flows, the presumed lowermost units of the volcanic sequence are in fault contact (the Paradise Sound Fault) with Cambrian and older clastic sedimentary rocks of the Musgravetown Group, Random Formation and Bonavista Formation to the east. These flows are commonly porphyritic and may include porphyritic intermediate flows. Higher in the sequence, lithic tuffs with a mafic matrix give way to crystal-lithic tuffs, rhyolite flows and (welded?) tuffs. Small-scale interlayering of these units can be observed in the field, so this stratigraphy is a simplification of a more complex interlayered sequence. More detailed stratigraphy is not yet available, due to the apparently discontinuous nature of the members along strike, and the difficulty in distinguishing depositional repetition from structural repetition. Water-lain sediments are few, but the sequence is overlain conformably (Hussey, 1978a,b) by graywackes and conglomerates of the Sandy Harbour River Formation. The Swift Current Granite outcrops within the volcanic sequences.

DESCRIPTION OF ROCK UNITS

The volcanics can be divided into a predominantly mafic unit, and a predominantly felsic unit. Locally, large areas of either mafic or felsic rocks are suitably divided by this method. In other places, interlayering and intrusions make this binary classification more difficult, and the definition of contacts less precise.

Unit 1

These rocks include dark green to black, porphyritic to massive mafic flows and dark purple porphyritic flows, possibly of intermediate composition. Crude joint sets commonly occur.

Dark colored lithic tuffs are also included. They contain fragments up to 40 cm in diameter that have been flattened on a pervasive, well developed cleavage. This cleavage, striking 030°-040° and dipping vertically to steeply northwest is present in all the volcanics, but is only poorly developed in the more massive, mafic flows.

Unit 2

Crystal-lithic tuffs, crystal tuffs, rhyolite porphyries and probable welded tuffs are the main rock types included in Unit 2. The crystal lithic tuffs are light gray and brown, and include flattened fragments usually less than 20 cm wide. On Hickey's Brook (south of Hickey's Pond) and its main tributary from the west, these tuffs contain pink granite clasts, indistinguishable from the major lithology of the Swift Current Granite. These rocks pass gradationally into crystal tuffs.

Quartz-feldspar porphyries are common where the Swift Current Granite is in contact with this unit. Rounded quartz crystals up to 1 cm in diameter and lesser feldspar occur in a light gray vitreous, siliceous matrix. Their contact with the granite may be gradational in places, which would suggest they are intrusive porphyries at the margins of the granite. However, they are also found kilometres from outcropping granite and are locally seen to contain small, flattened lithic fragments, suggesting an extrusive origin.

Some of the crystal tuffs have a fine banding similar to flow banding, but it is unbrecciated and the tuffs cover large areas. Intense flattening of lithic (ash?) fragments is not accompanied by deformation of crystals. These tuffs are tentatively interpreted to be ignimbrites.

Mafic and felsic dikes are comon in this unit. The felsic dikes are ubiquitous in rocks close to and on strike with the granite. One outcrop of auto-brecciated rhyolite occurs in a quarry north of Monkstown Road.

Unit 3

Hussey (1978a,b) described these sedimentary rocks as being composed largely of volcanic detritus. He concluded that they are in conformable contact with the underlying volcanic rocks.

Unit 4

The Swift Current Granite is concordant to the regional 030°-040° fabric. It is widest in the north and thins towards the south-southwest, pinching out completely near the Monkstown Road. It is typically white to pink, medium grained equigranular biotite-hornblende granite and granodiorite. The regional fabric parallels its margins but is only locally developed in the granite. Weak to strongly foliated zones are most common where the granite narrows. Joint sets and faults are present.

Dikes of coarse granite intrude volcanic rocks at its western contact, north of Sandy Harbour River. In the same area, angular mafic xenoliths 50 cm in diameter are common in the granite.

Unit 5

East of the Paradise Sound Fault late Precambrian to Cambrian sedimentary rocks were mapped by O'Driscoll (1978). These consist of laminated green sandstone and siltstone; red to purple sandstone, shale and conglomerate and minor mafic flows and tuffs of the Musgravetown Group. White quartzite with interbedded green sandstone and siltstone of the Random Formation overlies the Musgravetown Group and is overlain by purple and green shale of the lower Cambrian Bonavista Formation.

Unit 6

The Ackley Batholith outcrops on the western side of the Burin Highway and was mapped by Hussey (1978a,b) and Dickson et al., 1980. In this area it consists of pink, coarse grained, biotite granite. It intrudes rocks of the Love Cove Group post-tectonically and has been dated at 355 ± 5 Ma (Bell et al., 1977).

LEGEND

DEVONIAN

ACKLEY BATHOLITH

6 *Massive, pink, coarse grained to megacrystic biotite granite.*

CAMBRIAN AND EARLIER

MUSGRAVETOWN GROUP, RANDOM FORMATION AND BONAVISTA FORMATION

5 *Laminated green sandstone and siltstone; minor red to purple cross-bedded sandstone, shale and conglomerate; minor mafic flows and tuffs. White quartzite with interbedded sandstone and shale. Purple to green slate with pink limestone nodules.*

CAMBRIAN OR EARLIER

SWIFT CURRENT GRANITE

4 *Medium grained, foliated to massive hornblende-biotite granite, granodiorite, and syenite.*

HADRYNIAN OR EARLIER

LOVE COVE GROUP

3 *Green graywacke to arkosic sandstone and conglomerate.*

2 *Predominantly felsic volcanic pyroclastics and flows. Locally altered to sericite (± pyrite ± pyrophyllite ± specularite ± alunite) schists. Minor mafic dikes, flows and tuffs.*

1 *Predominantly mafic flows, tuffs and dikes, with minor intercalated felsic tuffs.*

SYMBOLS

specularite showing and sample site	✖
sample site	×
geological contact (approximate)	— — —
fault (assumed)	~ ~ ~

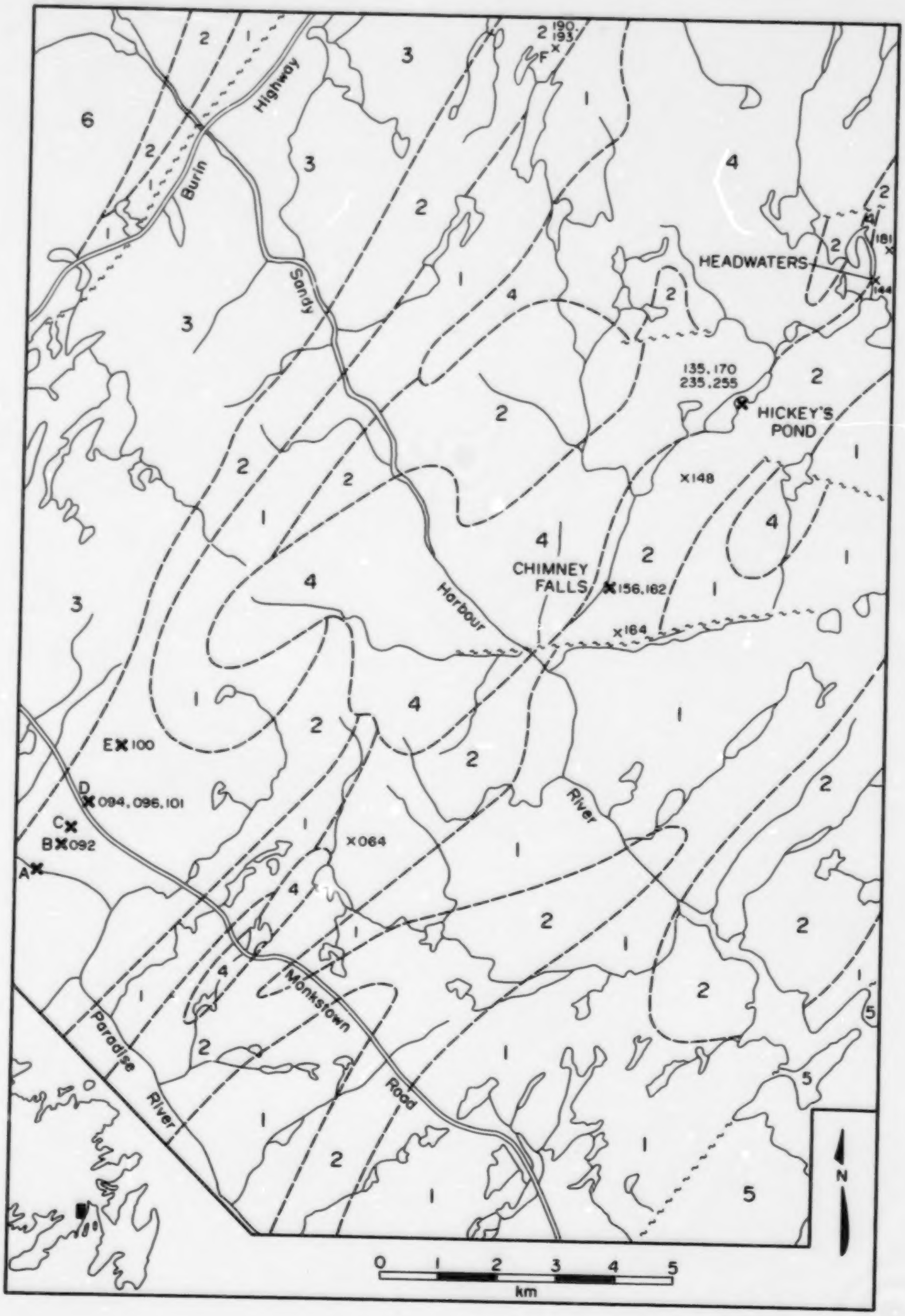

Figure 1: *General geology of the Hickey's Pond Belt.*

AGE RELATIONSHIPS AND GEOCHRONOLOGY

The Late Precambrian stratified rocks are a conformable sequence; however, the detailed stratigraphy is complicated by depositional and structural repetition. In general, mafic flows passing upwards through mafic lithic tuffs and felsic tuffs give way to coarse water-lain clastic sediments. Age relations between the granite and volcanics are contradictory. Whereas dikes of granite in the volcanics suggest the granite is younger, clasts of granite in certain tuffs suggest it is as old or older than these tuffs. These observations can be reconciled if the intrusion is considered to be synvolcanic.

This interpretation is supported by the geochronologic investigation of Dallmeyer et al. (1981). Crystallization dates for the granite and volcanic rocks were 580 ± 20 and 590 ± 30 Ma respectively, by U-Pb determinations on zircon fractions. They concluded that the rocks are comagmatic, and that the granite is subvolcanic.

STRUCTURE

Most of the volcanic rocks have a well developed cleavage which strikes 030°-040° and dips vertically to steeply northwest. Most dikes, quartz veins and contacts between flows are parallel to this regional fabric. Clasts in lithic tuffs are flattened on this plane. This hindered positive identification of bedding and prevented determination of younging directions. The cleavage is thought to be axial planar to isoclinal folds with an associated flattening of clasts. Other evidence of folding is the occurrence of tightly folded quartz veins. A single cleavage bedding intersection on Paradise River shows that the beds there are upright. It also shows that the clasts are flattened on the cleavage plane, not the bedding plane which is at a 30° angle to cleavage. Dallmeyer et al. (1983) dated sericite which had crystallized on this regional fabric by $^{40}Ar/^{39}Ar$ age spectra. Two samples from this study area yielded ages of 386 ± 10 Ma and 388 ± 10 Ma. They concluded that the deformation and recrystallization occurred during the Devonian Acadian Orogeny.

The regional fabric is only locally developed in the granite in this area, which has been shown to be pretectonic (Dallmeyer et al., 1981; 1983). It is cut by numerous joint sets and small faults.

A consistent trend is defined by three of the larger faults which all strike 080°. Among the smaller faults which parallel this trend is one which cuts the granite and the alteration zone at Hickey's Pond.

ECONOMIC GEOLOGY

Alteration

Felsic tuffs of Unit 2 have undergone variable degrees of alteration to sericite ± pyrophyllite ± specularite schists with or without pyrite. This alteration has occurred in two belts which parallel the regional fabric, an Eastern belt on the eastern contact of the Swift Current Granite, and a Western Belt to the southwest of the granite. The specularite occurs in three forms, all of which are present in both belts; these are: (1) as smeared bands in deformed schists, (2) as fine disseminations in siliceous rocks which are probably exhalative and (3) as platy crystals in quartz veins.

The Eastern belt of alteration is 9 km long and has 2 specularite showings; the Hickey's Pond deposit and the Chimney Falls deposit. The deposit at Hickey's Pond is very siliceous and rises almost 20 m above the pond and swamp. It consists essentially of banded exhalative rocks with varying amounts of specularite and alunite. Quartz veins with platy specularite cut the deposit, parallel to the regional fabric. Pyritiferous rocks are also abundant.

The Chimney Falls deposit is 4 km to the south-southwest of Hickey's Pond. It consists predominantly of soft sericite-pyrophyllite-specularite schists which are in fault contact with the Swift Current Granite to the west. Waterfalls 10 m high mark the place where Hickey's Brook flows from the granite into the easily eroded schists. X-ray diffraction work using the technique of Papezik et al. (1978) showed that one sample of this schist contains 81% pyrophylite.

At numerous other locations in this belt there are occurrences of sericite ± pyrophyllite schist with or without pyrite. Among these is a pyritiferous-sericite-pyrophyllite schist zone at the headwaters of Hickey's Brook, 3 km north-northeast of the Hickey's Pond deposit. A coarsely spaced cleavage crenulates the schistosity there. The schists are in fault contact with the Swift Current granite to the west. Another deposit 800 m northeast of there was shown to have 66% pyrophyllite (Hussey, 1978b).

The Western belt of altered volcanic rocks contains the specularite showing found by Tuach (1984) and four others discovered in the course of this study. The five showings span 2.5 km, with numerous schists between them. The occurrence 20 m north of the Monkstown Road (Location D) is similar to that at Hickey's Pond but is smaller and contains lazulite in the quartz veins. A small road cut on the Monkstown

Road 200 m west has exposed pyritiferous sericite schists with a thin, conformable chert body interbedded. The showing to the south of here (Location C) is smaller still but also has lazulite and platy specularite in quartz veins. Approximately 300 m south of this is another body (Location B) as large as the one on the Monkstown Road. Specularite-rich bands up to 15 cm thick, alternating with white to tan chert have been complexly folded. This outcrop stands a few metres above the low-lying, swampy surroundings, as do those at locations C and D. These three occurrences (Locations B, C and D) are very siliceous and relatively resistant to erosion. They are the middle three occurrences in this belt of five.

Specularite showings are also found both north and south of these three (Locations A and E). These showings are soft, deformed specularite-sericite schists surrounded by abundant pyritiferous schists.

Minor specularite in quartz veins occurs along strike with the western belt (Location F), 13 km north-northeast from the northernmost showing. The intervening distance is mostly barren of alteration and specularite mineralization, though minor pyritiferous schists were found.

The Eastern belt of alteration is found in felsic tuffs of Unit 2 that are in contact with the Swift Current Granite to the west. At Chimney Falls and the sericite-pyrophyllite schist showing at the headwaters of Hickey's Brook, the altered rocks are in fault contact with the granite to the west. To the east, alteration diminishes and the rocks pass from unaltered felsic tuffs to mafic volcanics. The zone is terminated on the north, where the volcanics pinch out into granite. To the south, the alteration has not been traced beyond the 080° striking fault 1 km south of the Chimney Falls showing. It seems however, that the volcanics of unit 2 continue to the south of the fault, having undergone apparent dextral displacement (see map). These rocks should be explored further for alteration zones, especially since the granite outcrops to the west, as it does over the length of the known Eastern alteration belt.

The Western belt of alteration is more distant from the granite, but examination of the map shows that it is approximately on strike with the northwestern flank of the granite. However, a narrow belt of mafic volcanics separates the alteration belt and the granite. Possibly, this means that the granite in the Western belt did not intrude as highly into the sequence as it did near the Eastern belt. Rocks on strike with the Western belt, south of Paradise River were not examined. Given the apparent continuity of this belt, however, this area deserves further study.

GOLD ASSAYS

Rock samples were analyzed for gold by neutron activation by Chemex Ltd., Vancouver. Table 1 shows the data for 16 of the 137 samples analyzed. For a more complete list of the analyses see O'Driscoll and Huard (1984). By considering these data, and the locations of the samples, the following inferences can be drawn:

(1) Gold concentration in any given rock type can vary profoundly; e.g. samples 092 and 235 are, at least megascopically, similar. However, their gold concentrations are 5 and 5400 mg/t respectively.

(2) The soft, sericite-pyrophyllite schists with and without specularite and/or pyrite generally have low (200 mg/t) gold concentrations.

(3) The highest gold concentrations are found in (exhalative?) siliceous bodies, usually with disseminated specularite, but all such rocks do not have high concentrations (e.g. sample 092).

(4) The eastern belt, especially the Hickey's Pond deposit, has the highest gold concentrations.

DISCUSSION

The proximity of the highest gold values to the Swift Current Granite may suggest a genetic relationship with the granite. However, it must be remembered that the contact with the volcanics is faulted and their relative positions at the time of mineralization is the critical factor when considering the relationship to the granite. The Swift Current Granite may best be modelled as the core of a gently south-southwesterly plunging anticline. Granite is also found isolated (in map view) from the main granite body, e.g. the small body which crosses the Monkstown Road. Granite may be present at shallow depths, under the volcanics on the flanks and nose of the anticline. Therefore, the presence of outcropping granite is not a necessary prerequisite in considering further exploration for auriferous alteration zones.

The area exhibits characteristics similar to "epithermal" gold producing areas in the volcanic environments in the southwestern United States and western Canada (Buchanan, in press; Panteleyev, 1984) and the Carolina Slate Belt (Worthington and Kiff, 1970; Spence et al., 1980; Worthington et al., 1980). These characteristics include the alteration assemblages (sericite-pyrophyllite-alunite) and the presence of siliceous exhalations. Structural similarities have not been observed, probably due to the intense deformation in the study area.

CONCLUSION

Elevated gold concentrations have been demonstrated for certain rocks in this study area. The most promising area thus far is the quartz-specularite- alunite deposit at Hickey's Pond. In evaluating the area's gold potential, the following factors must be considered: (1) The deposit north of the Monkstown Road is a recent discovery (1983) and in 1984 this study showed it to be part of a belt at least 2.5 km long with elevated gold concentrations. Other promising areas may include southern continuations of the two alteration belts described here. (2) Regional examination indicates that similar volcanic units extend for tens of kilometres both north and south of the study area. (3) Similar altered volcanic assemblages occur throughout these late Precambrian volcanic rocks on the Burin Peninsula and have not been prospected for gold.

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TABLE 1

SAMPLE ≠	SAMPLE DESCRIPTION	Au (mg/t)
064	pyritiferous quartz sericite schist	10
092	siliceous rock with abundant disseminated specularite	<5
094	sericite-pyrophyllite schist	<5
096	siliceous rock with abundant disseminated specularite	<5
100	sericite-specularite schist	<5
101	pyritiferous quartz-sericite schist	<5
135	chert with fine specularite-rich bands	350
144	pyritiferous sericite-pyrophyllite schist	10
148	quartz-sericite schist	<5
156	specularite-rich band in chert	335
162	pyritiferous quartz-sericite-specularite schist	105
164	pyritiferous quartz-sericite schist	<5
170	quartz vein with pyrite	2530
181	quartz-sericite schist	100
190	chlorite-sericite schist	<5
193	quartz vein with minor specularite	<5
235	fine specularite in chert	5400
255	massive, fine-grained specularite	4710

Table 1: *Gold analyses for selected samples in the Hickey's Pond Belt.*

INDUSTRIAL MINERALS SURVEY - 1984

by

A.F. Howse and C.J. Collins*

INTRODUCTION

Attention again focused on barite during the 1984 field season. Activities were concentrated in two areas of southeastern Newfoundland, mainly as a follow-up to work done in the previous two field seasons. A brief survey was undertaken on the Isthmus of Avalon in an attempt to explain some of the barium anomalies revealed by a 1983 regional stream sediment survey (Howse et al., 1984). On the Burin Peninsula, a stream sediment survey was conducted in and around the St. Lawrence fluorspar district. Although that region has potential of hosting a wide range of mineral deposits (Strong et al., 1978),the primary objective of the survey was to help assess the potential for fluorite-barite minerali-zation in the outer fringe areas of the district. There, mineral occurrences in the form of fluorite-barite-galena veins and fluorite-barite float are well documented (Smith, 1957), and significant deposits of these minerals may be present. Other industrial mineral commodities briefly investigated in 1984 included a little known deposit of diatomaceous earth near the community of Victoria and brick shales on the Port au Port peninsula.

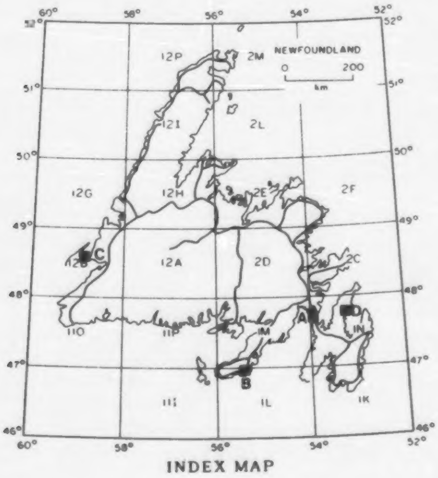

Figure 1: *Field study areas during 1984 field season (A) Avalon isthmus; (B) St. Lawrence area; (C) Shoal Point; and (D) Victoria/Carbonear areas.*

WESTERN AVALON PENINSULA

Previous Barite Assessment

Because of the wide distribution of vein deposits of barite throughout the western Avalon Peninsula, that area has been the focus of attention during the past three field seasons. Geologically, the region is underlain by a sequence of sedimentary and volcanic rocks belonging to the Upper Precambrian Connecting Point and Musgravetown Groups and to various Lower Cambrian formations. Barite, with or without quartz, occurs in veins cutting strata of all ages. On the eastern side of Placentia Bay, barite is present in the La Manche galena-calcite vein (Green, 1981), and as a very minor gangue mineral at the Silver Cliff lead-zinc-silver vein near Argentia (Chute, 1939). Specifically, the Isthmus of the Avalon and the St. Brides areas have been subjected to more intense investigations. Initially, the coastlines of both areas were surveyed by boat, inland areas were traversed by foot and highway and railway rock-cuts were examined. Numerous new, narrow, high grade veins of barite were discovered during the course of the 1982 project (Howse and French, 1983).

Typically these consist of salmon-pink, bladed or tabular crystal aggregates, occupying small fissures and commonly associated with quartz and/or calcite. Faults which cross-cut the regional northeasterly structural trends are readily discernible on air photographs; those that parallel these trends are not as apparent. On the Bellevue Peninsula, several composite veins with varying proportions of barite, quartz and calcite were discovered. There, the most significant veins in terms of width and grade of barite occupy fractures that trend approximately north-south. The Colliers Point vein to the immediate south, first mined early in the century and sporadically reactivated in recent years, occupies an approximately north-south trending fault.

In 1983, the Mineral Deposits Section, in a coordinated effort with the Geochemical Section, carried out stream sediment surveys in two areas of the Western Avalon Peninsula. The projects conducted in the Isthmus of the Avalon and the St. Brides

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This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

areas were aimed at assessing both industrial mineral and base metal potential. Prospecting for mineralized float and outcrop was also an integral part of the stream traverses. During the course of the field work additional barite veins were discovered on the Bellevue Peninsula, in the northern part of the Isthmus near Jack's Pond (Howse and Collins, 1984), and at Cuslett, near St. Brides. A new barite-lead vein was discovered near Southern Harbour. Most of these deposits have subsequently been staked and results of the stream sediment surveys have been released on open file (Howse et al., 1984).

Avalon Follow-up - 1984

A brief period in June was spent traversing some of those streams, which contained anomalous amounts of barium in their stream sediments. Only a few streams were traversed and water levels were high. The aim was to examine the bedrock of the immediate drainage area for barite mineralization where it was located in four out of the seven anomalous areas. The strongest anomalies occur in streams which drain areas underlain by rhyolitic rocks of the Bull Arm Formation. In fact the concentration of barium in one stream, which flows in a northeasterly direction into Broad Lake, (maximum 24,964 g/t) suggests that some form of physical concentration of the barite is present in the stream sediment. This is probably accomplished through erosion of the host rock and the barite followed by gravity settling of the denser barite. Near the stream, barite and quartz occur as films along fractures and joints in rhyolite on the north side of the stream valley. Because of its high specific gravity, barite may have become segregated into highly anomalous zones in the streams, through the action of water.

An investigation of a barium stream sediment anomaly near the Old Rantem Station resulted in the discovery of barite mineralization within a few metres of the sample site. Stringers and veinlets of gray-pink and reddish-pink barite cut red medium-grained sandstone. The northeast trending zone, which dips steeply to the southeast, can be traced for about 5 metres. Hematite coated slikensides occur in the footwall.

Barite was also found about 1 km southwest and along strike from the Little Southern Harbour barite-lead vein, discovered in 1983 (Howse and Collins, 1983). The vein is about 15 cm wide and consists of pink and reddish-pink bladed crystals of barite. It is exposed in the north bank (cliff) of the stream, strikes 028° and dips subvertically. The host rocks are siltstones of the Connecting Point Group. The stream sediments downstream of the vein are anomalous in both barium and lead, although no lead mineralization was seen. Overburden covers the top of the 3 metre cliff in which the vein is exposed.

A barite occurrence at Bellevue reported by McCartney (1956), was also investigated. This was the only inland occurrence of barite shown on McCartney's map. The 20-50 cm wide vein consists of pink, platy barite with numerous inclusions of country rock. It strikes 020°, dips vertically and can be traced 4 metres along the stream bed in which it is exposed. Stream sediment a few metres downstream from the vein contain anomalous concentrations of barium.

ST. LAWRENCE AREA

Fluorite-barite Mineralization - "Outer" Veins

A stream sediment survey was carried out in the St. Lawrence fluorspar district on the Burin Peninsula during the 1984 field season (Figure 2). Although the area has potential for hosting a wide range of mineral deposits (Strong et al., 1978) the primary objective of the survey was to help assess the potential for fluorite-barite mineralization of the northern part of the district. The project area is underlain by Late Precambrian volcanic and sedimentary rocks, Cambrian sedimentary rocks and the Carboniferous St. Lawrence Granite, the latter being the principal host rock for the area's fluorite mineralization. Studies of the genesis of the fluorite veins (Teng, 1974; Teng and Strong, 1976; Collins, 1984) have supported hypotheses by Van Alstine (1948) and Williamson (1956), that the granite and fluorite had a common source, i.e. a magma chamber that released ore fluids during late stage differentiation. These formed fluorite veins along faults and shears in the granite as it cooled and contracted. Veins of fluorite with an associated barite content ranging up to 30 percent, occur in a number of widely scattered locations north of Lawn and St. Lawrence. These, which include the Big Meadow Woods, Anchor Drogue, Lunch Pond, Devils Kitchen, Tilt Hill and Clam Pond veins, were collectively referred to as "outer" veins by Smith (1957) because of their location in the peripheral region of the distinct. The following arebrief descriptions of some of these deposits based on the authors' own field observations and experience in the area, as well as data from the Department of Mines and Energy geofiles. The description also includes that of the Lawn Barite vein, a relatively newly (1984) discovered vein uncovered by a road construction crew in the community of Lawn.

LEGEND FOR FIGURE 2

CARBONIFEROUS
6 *St. Lawrence Granite*

CAMBRIAN
5 *Inlet Group (clastic sedimentary rocks)*

PRECAMBRIAN
4 *Marystown Group (subaerial volcanics)*
3 *Burin Group (submarine basalts)*

INTRUSIVE ROCKS
2 *Loughlins Hill Pluton (gabbro)*
1 *Anchor Drogue Pluton (granodiorite)*

Abbreviations

ba	*Barite*
dum	*Dumortierite*
fl	*Fluorite*
py	*Pyrite*
pph	*Pyrophyllite*
Cu	*Copper*
Pb	*Lead*
Mn	*Manganese*
Mo	*Molybdenum*
Ag	*Silver*
U	*Uranium*
Zn	*Zinc*

SYMBOLS

Fluorite vein	xxxx
Mineral occurrence (dumortierite)	✕dum
Mineralized float	△

Meadow Woods Vein

The Meadow Woods vein is by far the most important of the "outer" veins of the district. Discovered in 1944 by Aloysius Molloy and Louis Kelley, about 4 km north of Lawn, early workers traced it for approximately 600 m along its east-west strike. The width of the vein decreases eastward, averaging 3.6 m for 180 m, then 1.8 m for the next 180 m and gradually narrowing to about 1.2 m for the remaining strike length.

In the 1950's Newfoundland Fluorspar Limited sank a 12.2 m shaft into the vein to learn more about its characteristics at depth, and to establish the relative proportions of the different minerals (fluorite, barite, galena). The average analyses (Smith, 1957) of 12 run-of-mine samples taken while shaft-sinking were:

CaF_2 - 58.8%
$BaSO_4$ - 15.1%
$CaCO_3$ - 0.6%
SiO_2 - 19.5%
Pb - 2.2%

Fluorite and barite was found to be mixed intimately but the galena was concentrated in a 15 cm wide band in the vein.

Alcan (1976) drilled eleven holes along the vein structure. Drilling confirmed the high fluorite content of the vein but the core was not assayed for $BaSO_4$.

The Big Meadow Woods trenches were examined by the authors in 1983. Rubble in the trenches consists of blocks of barite-rich, white fluorite; the barite is pink and salmon in color. The barite occurs as fine-grained bands and crystal aggregates with fluorite and quartz. Malachite was also observed. Barite is estimated to comprise up to 20% of the vein. Smith (1957) concluded from his examination of the vein, as exposed in the trenches, that it contained barite sufficient to make up one-quarter to one-third run of the mine ore, and our observations tend to support that view.

Big Meadow Woods - East Extension Vein(s)

Extensive barite float was also noted in trenches about 6 km northeast of Lawn. The barite displays pink and white banding and has a bladed crystal texture. White, purple and green varieties of fluorite were noted. Minor galena and pyrite are associated with the barite and fluorite. The trenches were dug by David S. Robertson Associates Limited (1972), who explored a series of airborne VLF anomalies in the area. The anomalies trend toward the Meadow Woods vein, some 2.5 km to the west. These anomalies were tested by a series of three diamond drill holes in the immediate area of the trenches. Hole 72-4 (45°) intersected extensive barite-fluorite mineralization in granite from 13.9 m to 46.0 m. The hole log describes a system of parallel veins, up to 1.3 m thick, occurring in fractured, hematized, kaolinized, granite. Barite and fluorite occur in brecciated and silicified zones; galena was also noted. In most of the veins barite is the dominant mineral, but in some, fluorite is proportionally greater. The log notes several kaolinized zones, described as faults in the section, in which the rock was very incompetent and core recovery was extremely poor. The log also notes that the mineralized fault zone was intersected at a 45° angle. It is possible that this zone is an eastward extension of the Big Meadow Woods Structure.

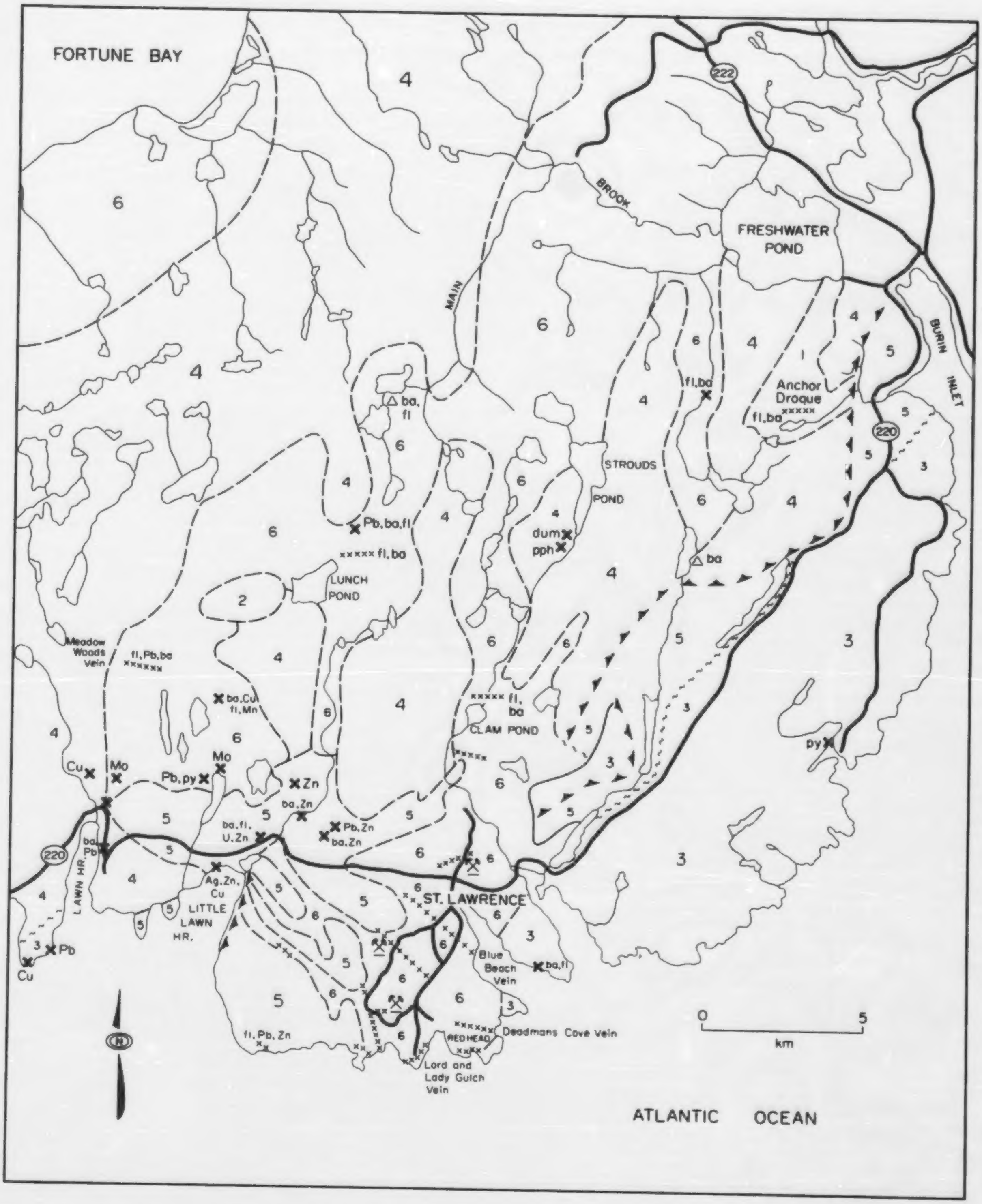

Figure 2: *Geological map of St. Lawrence area.*

Anchor Drogue Vein

The Anchor Drogue vein lies 3.2 km west of Salmonier or about 20 km northeast of the town of St. Lawrence. The vein occurs along a fault which cuts volcanic rocks of the Marystown Group and granodiorite of the Anchor Drogue Pluton. Its attitude is 085/65°N and it has a maximum exposed width of 1.5 m. The vein is composed mainly of green-white coarsely crystalline fluorite, displaying prominent zoning with barite-rich bands on the hangingwall and footwall. Galena occurs as blebs and crystals scattered throughout the vein.

The Anchor Drogue vein was tested by 4 diamond drill holes in the 1950's (Newfoundland Fluorspar Limited) and 14 holes in the early 1970's (Allied Chemical Corp). The latter program indicated a reserve of about 15,000 tonnes of 40 - 50 percent CaF_2 and about 15 percent barite, in a shallow vein deposit.

Lunch Pond Vein

The Lunch Pond vein is located near the northern tip of Lunch Pond, about 11 km northwest of St. Lawrence. Discovered by Newfluor prospectors in 1950 the vein was trenched and diamond drilled. Although the trenching showed only a 60 cm wide vein, subsequent drilling indicated extensive mineralization. The best results from the holes drilled showed a cumulative total of 8.4 metres of fluorite contained in three sections of 1.2 m, 4.2 m, and 3.0 m respectively. The average grade was 58.8 percent CaF_2, including the 3 m section which averaged 66.5 percent CaF_2.

The vein which is hosted by St. Lawrence Granite, appears to strike about N65°E and dip 80°N; its strike length is unknown. The vein contains a mixture of fluorite, barite and calcite with minor galena. Barite is proportionally less than that contained in the Big Meadow Woods vein.

Clam Pond Vein

The Clam Pond vein outcrops on the west side of a stream which flows into the northeast end of the pond. Large angular chunks of red and salmon-pink barite with white and blue fluorspar were observed in the stream bed, near a small notch which marks the site of the vein. Van Alstine (1948) observed the vein in place and reported that much of it consisted of alternating bands (up to 1 cm wide) of red platy barite and white fluorite. Galena and sphalerite were also noted. The vein is hosted by the St. Lawrence Granite.

Devil's Kitchen Vein(s)

During the stream sediment survey numerous trenches containing large blocks of white and pink barite float were noted east of Main Brook Pond about 16 km north of St. Lawrence. These trenches are undoubtedly those described by Smith (1957) as containing extensive barite float. Host bedrock is visible in only one trench; there it consists of mineralized pink, medium to coarse-grained granite with finer aplitic zones. Green and white fluorite and pink platy barite, as well as minor galena, occur as float. Dimensions of the mineralized blocks indicate vein widths of 30 cm or more.

Lawn Barite Vein

The Lawn Barite vein was discovered in 1982 during road construction through the community of Lawn. The following description of the vein is a condensed version of an account by Collins (1984). The vein is located on the eastern side of Lawn Harbour and occurs in the Webbers Cove Conglomerate, part of the Upper Proterozoic Marystown Group, a sequence of dominantly subaerial volcanic rocks, which outcrop throughout the Grand Bank and Lamaline region. (O'Brien et al., 1977). The mineralization, exposed in a 25 m wide roadcut, consists of granite, fluorite, galena and sphalerite in two zones on either side of the road. The main vein, which is located on the southern side of the road, strikes 105°, dips almost vertically, and can be traced for about 25 meters along the outcrop. The vein widens with depth from only 15 cm at sub-outcrop level (1 m below surface) to 60 cm at the road level (about 4 m deeper). Two smaller veins (10 cm wide) were noted near the main vein and may be offshoots from it.

The mineralization in the main vein is primarily pink to white barite with intergrown fluorite and minor zones of galena and sphalerite. Some narrow zones of massive galena and sphalerite are also present. The more massive sections of the vein are characterized by banded white and pink barite, with intimately intergrown fluorite, together with minor bands of massive galena and sphalerite. Breccias are common, and consist of conglomerate fragments within banded crystalline barite and fluorite. Conglomerate with a matrix composed entirely or partially of barite, fluorite and calcite with or without veins or veinlets, is also common.

The conglomerate is relatively unaltered, coarse grained, and has a sandy matrix. Fragments are generally well rounded and include sedimentary and volcanic rocks together with fragments of granites or porphyry. Near the vein the conglomerate is altered over a 20 m width; the alteration zone consists of white to yellow clay minerals, presumably of hydrothermal origin.

Stream Sediment Survey

The stream sediment survey covered an area of about 200 km^2 and encompassed all of the fluorite and barite occurrences described above as well as a wide range of other metallic and non-metallic mineral occurrences (Figure 1) in the project area. The topography of the area is a reflection of bedrock type and the effects of glaciation. Volcanic and sedimentary rocks form high, rounded hills, while the granite usually underlies areas of low relief. Glacial features such as roche moutonnées, drumlins, and glacial till characterize the area, the latter having its greatest thickness in valleys and depressions. The region is generally dotted with small bogs and ponds. Wooded areas are sometimes present in stream valleys and on hillsides. The main drainage system is poorly developed and runs from north to south. However, many small streams run an irregular pattern between ponds and bogs.

Stream sediment samples were collected at 400 m intervals, however, this spacing varied considerably for some streams. The number of tributaries, connection between ponds and small brooks flowing into ponds sometimes resulted in more detailed sampling of an area than was originally planned.

Over 650 samples were collected. Descriptive data was routinely recorded for each sample and duplicates were taken for control purposes. The samples will be analyzed for a suite of elements including Ba, Sr, Cu, Pb, Zn, Ag, Fe, Mn, F, Co, Ni, Mo, U, Sn, W, and L.O.I. The results will be released on open file when they become available.

DIATOMACEOUS EARTH

Victoria - Carbonear

A cursory examination was made of the diatomaceous earth deposit which lies near Beaver Pond within the community of Victoria, Carbonear (Figure 3) This deposit was first recognized by N. Sutton, a resident of the area, who reported it to the Mineral Resources Division in 1963. The deposit was examined by Fletcher (1964) who, using a Swedish sampler (a device originally designed for testing peat), drilled 13 holes in the bog at the western end of the pond, and 7 holes in the pond itself. He estimated that there are approximately 65,700 tonnes of diatomaceous earth under Beaver Pond and considerably less than that under the bog. Fletcher recommended more detailed logging with subsurface contouring and laboratory testing.

The 1984 field work was aimed at obtaining samples of the deposit for laboratory tests. Using a Swedish sampler, samples were taken from the bog at the western end of Beaver Pond; as well as the pond itself (see Figure 2). Diatomaceous earth was encountered in all of the holes. Generally the deposit exhibits a fairly well defined layering with seemingly pure white material (30 - 60 cm thick) overlying a gray silty mixed layer (30 cm+). In some holes the white diatomaceous earth was encountered immediately on the surface and in others it was capped with peat. The test holes were limited to a depth of 3.6 m because of rod extensions. Descriptive logs were recorded for each hole and samples taken of the diatomaceous earth for laboratory tests.

BRICK SHALE

Shoal Point - Port au Port

A brief period was spent investigating shales of the Port au Port Peninsula in light of their potential industrial uses. The shales, together with minor sandstone and limy beds, form part of the lowest structural slice of the Humber Arm Supergroup (Williams et al., 1979). Shoal Point, on which the sampled shales are exposed, is a low-lying, uninhabited point of land projecting northwards for about 9 kilometers into Port au Port Bay (Figure 4). Its elevation does not exceed 15 m and most of the land averages about 3 - 4 meters above sea level. Harris (1962) sampled shales along the east shore of Shoal Point and concluded that the area had excellent potential for a brick shale quarry. He estimated a total reserve of about 7 million tonnes, assuming that 2.1 m of shale could be quarried above sea level. However, Harris's estimate is based on his observations of shale thickness on the east side of the point. On the west side there is much less exposure above sea level and most of the coastal exposures are covered at high tide. Correspondingly the thickness of peat on the west side of the point increases 3.6 m meters. Therefore, the reserve estimate of Harris (1962) may be too high, although substantial, amounts of quarryable material probably exist.

The shales in the Shoal Point section are red, green, black and highly fissile; minor sandstone and limy beds were also noted. Some of the beds contain large crystalline concretions of pyrite and marcasite. The shales are folded and faulted, and dips up to 50° were noted. The elevation of shale exposures averaged 2.2 m

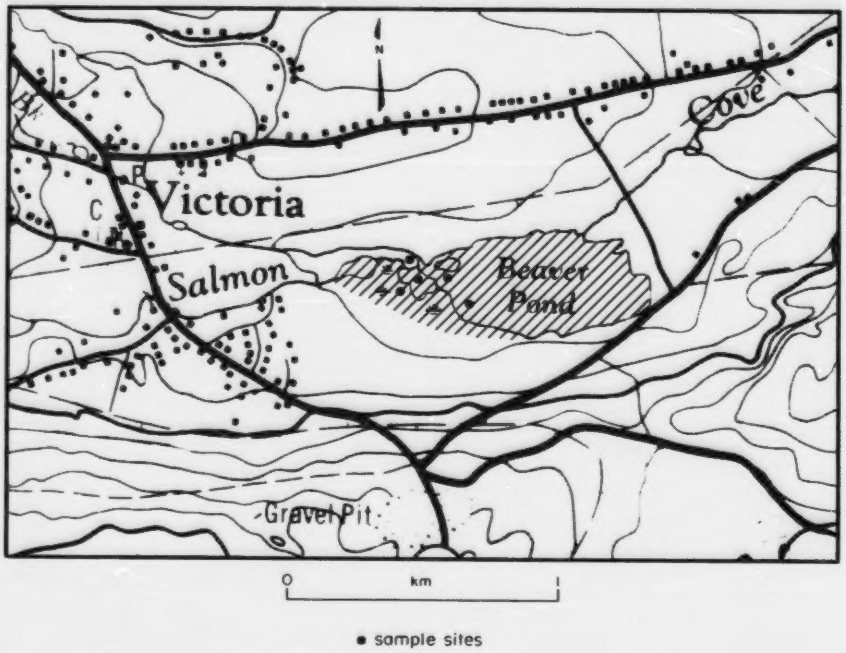

Figure 3: *Location of the diatomaceous earth deposit near the town of Victoria. The deposit (shaded area) underlis Beaver Pond and the bog at its west end.*

above sea level in the sampled area on the east side of the point; exposures on the opposite shore are weathered down to sea level. The peat cover has a maximum thickness of 2.4 m on the east side of the point and 3.6 m on the west side. A total of six bulk samples were collected at 500 m intervals from both sides of the point. Chemical analyses and firing tests on the shales will be carried out in order to determine their suitability for the brick and cement industries.

ACKNOWLEDGEMENTS

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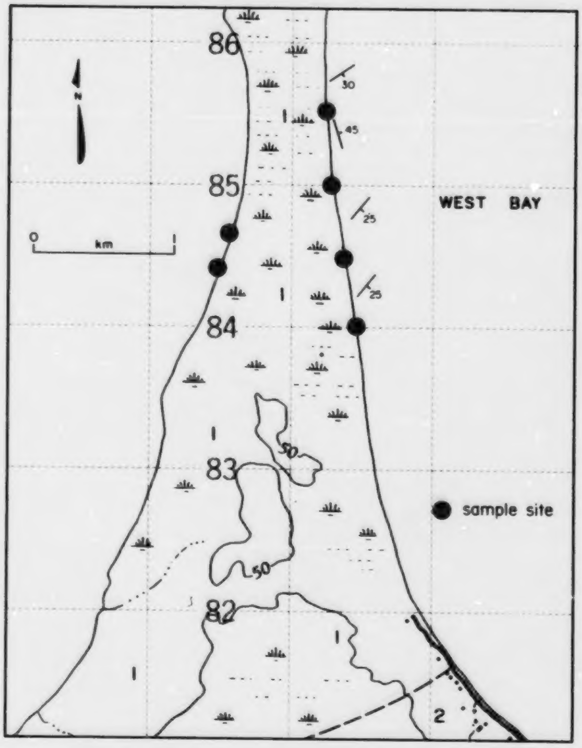

LEGEND

MISSISSIPPIAN

2 *Codroy Group: Limestone, shale, sandstone evaporites.*

HADRYNIAN TO MIDDLE ORDOVICIAN

1 *Humber Arm Supergroup: Red, green, and black highly fissile shales, scattered pyrite and marcasite concretions, sandstone, conglomerate, minor limestone.*

Figure 4: *Sketch map of the Shoal Point/ Port au Port Peninsula, showing sample site locations.*

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AGGREGATE RESOURCES INVENTORY
(With Reference to the Location of the Silica Sand Deposit for North Star Cement Prodution)

by

Dan Bragg
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ABSTRACT

Since 1975 the Aggregate Resources Inventory has developed into a system, flexible enough to meet the needs of various users, (e.g. Quaternary Geology project geologists other government departments and industry).

The data base system used is the Scientfic Information Retrieval System or SIR. The system is used for the storage and retrieval of aggregate and geology data.

Apart from the SIR system, the section is also providing information upon requests from companies and individuals, (e.g. pebble lithology data for Dr. Ian Brookes, and silica sand investigation for North Star Cement).

INTRODUCTION

The Quaternary Geology Section has been collecting aggregate resource data (Kirby et al., 1983) throughout the province since 1975. To date, approximately 12,000 samples have been collected. The data base management system selected for the manipulation of the data is the Scientific Information Retrieval (SIR) system. The end product is the Aggregate Resources Inventory System, an interactive data base designed for the storage and retrieval of aggregate and surficial geology data.

SIR SYSTEM

The system consists of a series of programs which permit the user to:

- edit data collected by the geologists
- correct any data which was coded incorrectly or omitted
- produce cumulative curve plots of gravel, sand, silt-clay percentages for individual samples
- produce various reports on paper or microfiche, e.g. master file report, lithological analysis report, particle-size-analysis report
- check the integrity of the data base for any changes since the last time it was accessed.

The data in the data base can be divided into two categories, information pertinent to a specific sample site or location, and information related to individual samples taken at the site. Of the sixteen record types defined for the data base, records 1 to 6 hold site information and records 7 to 16 hold information related to a particular sample. This gives the data base a hierarchical structure, i.e. each site record may have many sample records associated with it. Atkinson (1984) contains a more detailed report of the system.

The codes have been updated to remove ambiguity and redundancy. Also the forms used to collect the data have been modified to speed up the data entry process (e.g. the laboratory data are on a separate form from the field data, allowing separate keying and data entry (i.e. laboratory data keyed and entered at a later date).

As of August 31, 1984, the data base held information on 8689 sites, with approximately 44,345 records on file; and new data are continually being added.

The system is also being utilized by outside sources for scientific investigation (e.g. Dr. Ian Brookes used pebble lithology data collected in the Bonavista area to substantiate his ice movement theories). Data on textures of tills were supplied for inclusion in the volume on Quaternary Geology of the Atlantic Provinces Region for the Decade of North America Geology volumes.

AGGREGATE RESOURCES

Apart from the SIR system, it has also been a busy year dealing with requests for information on aggregate resources (e.g. approximately 70 requests from different companies and individuals involving 377 aggregate maps, 46 surficial maps, 437 aggregate graphs and 276 data sheets) and screening numerous Crown land application referrals and other land use proposals for conflicts with aggregate resource management.

INVESTIGATION

The Quaternary Geology Section was contacted by The North Star Cement Company requesting information on silica sand deposits which may be located in the Corner Brook area. A silica rich source was required to provide a fourth mix (Dave Stonehouse, personal communication) that could be used in the plant feed to reduce or control the amount of Al_2O_3 in the cement.

The SIR system was used to retrieve all data pertinent to the area. From the data, discriminatory sites and samples were chosen. Follow-up investigations consisted of (a) a visual analysis for quartz rich aggregates conducted on archived aggregate samples maintained at the Core Storage Building in St. John's and (b) chemical analysis of potential samples by North Star Cement. From this investigation a number of sites were chosen for field testing. Fred Kirby assisted with the field testing and sampling of one particular site at Steady Brook. Nine backhole test pits were dug in the area at an average depth of 4.9 meters. Eight out of the nine test pits showed high silica sand content greater than 90% silica. One test pit which showed low silica content had taken in the transition zone between the terrace and till deposit. Thus through this investigation the potential silica rich deposit in the terrace was confirmed and is presently being used by North Star Cement in their plant feed and cement. The site is under quarry permit to Joseph Batstone who has been contracted to supply North Star Cement.

CONCLUSION

The continued updating of the 1:50,000 and 1:250,000 aggregate maps and a series of Geotechnical Geology maps with descriptive notes and legends for Newfoundland, should be available by March 31, 1985. Compilation of the 1:1,000,000 scale summary maps for the island and Labrador is ongoing.

ACKNOWLEDGEMENTS

The author wishes to thank Joe Atkinson for his continued assistance and patience in helping me to understand the computer world.

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DETAILED AGGREGATE ASSESSMENT PROJECT - INSULAR NEWFOUNDLAND

by

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ABSTRACT

Detailed aggregate resource assessments were begun by the Department of Mines and Energy in 1979 as part of the Inventory of Aggregate Resources Program (Kirby et al., 1983). In 1982 a separate and ongoing program (Kirby, 1983) was started to identify, map and sample specific areas of the province where restrictive land use practices threaten to sterilize valuable nonrenewable aggregate resources.

Most of the work to date has been conducted in municipal planning areas where new plans are being developed or where plans are under review. Mapping has also been conducted in a number of areas where restrictive zoning (e.g. watersheds, forestry, etc.) threatens valuable aggregate deposits.

All information obtained from the survey is made available to the various planning agencies and to the general public upon request.

INTRODUCTION

This report summarizes the results of the detailed aggregate resources sampling program conducted in selected areas of Newfoundland during the 1984 field season.

Including the 1984 field work, a total of 32 planning areas have been completed, along with a number of special projects.

FIELD PROGRAM, 1984

Most of the 1984 work was again concentrated in municipal planning areas (Figure 1). These included Pasadena (12H/4), Cormack (12H/3 & 6), Grand Bank/Fortune (1M/4), and that portion of the Conception Bay North area between Victoria and Holyrood (1N/6, 11 and 14). Some follow-up work was also conducted in the Deer Lake area.

Other projects conducted in 1984 included: (1) backhoe test pitting in the Billy's Pond area, near Port aux Basques, to determine if the establishment of a protected watershed in the area would sterilize any valuable aggregate resources; (2) a reconnaissance level aggregate resources survey, using all-terrain vehicles and helicopters, along proposed road routes to the Cape Ray gold prospect on the south coast of Newfoundland and (3) in conjunction with the Mineral Deposits Section, five backhoe test pits in the Wild Cove clay deposit near Corner Brook. Five bulk clay samples were collected and sent to Ottawa for further analyses to determine their suitability for brick manufacture.

A total of 406 aggregate and rock samples were collected during the 1984 field season.

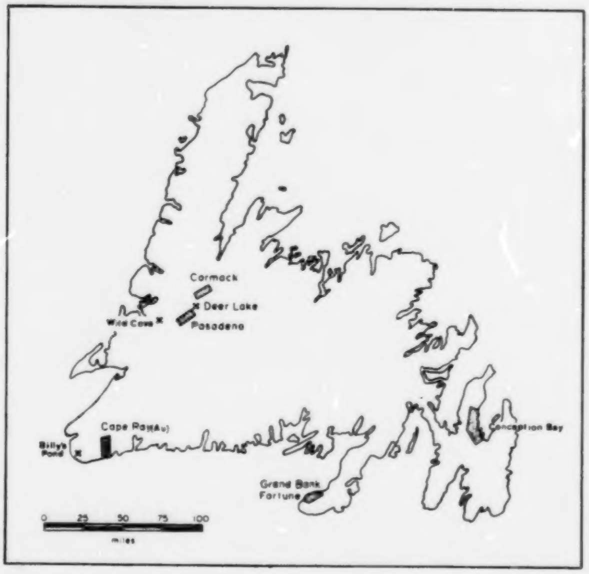

Figure 1: *Detailed Aggregate Resource Assessments.*

All samples collected containing +8 mm material were field sieved and a split of the -8 mm material was retained and sent to the laboratory for further sieve analysis (Kirby et al., 1983). A split of the +16 mm pebble fraction was retained for field petrographic analysis.

MUNICIPAL PLANNING AREAS

PASADENA - The study verified that the community has been constructed on a portion of a large glaciofluvial terrace deposit. The terrace is composed of stratified sand

and gravel that is greater than 8 m in depth. Private land ownership has virtually sterilized the remainder of the deposit. In addition, numerous cabin developments along the shore of Deer Lake has virtually sterilized all remaining potential aggregate sites in the study area.

Generally, the petrographic characteristics of the samples indicate that the gravels are not suitable for most high grade aggregate uses (e.g. asphalt or concrete). The glacial tills in the area are also generally very silty and of poor quality. A number of clay exposures were noted and sampled throughout the area. Visual inspection of these clay exposures revealed a high mica content, which would limit their use as a source of clay for ceramics or brick manufacture.

CORMACK - The area is covered by a thin veneer of local stony till over fractured siltstone and mudstone. These tills are very silty and are of poor quality for aggregate use.

A number of eskers composed mainly of sand with lesser amounts of stratified gravel occur in the area. These deposits are an excellent source of blending sand. The petrographic characteristics of the coarser gravels may limit their use as a source of high quality aggregate.

Bedrock exposures in the western portion of the area are mainly highly fractured Cambro-Ordovician marbles. Siltstone, sandstone and mudstone are common throughout the remainder of the area. One small siltstone quarry was noted in the area, but marble has been quarried extensively and is still the main source of coarse aggregates in the area. Approximately 70% of the land area is privately owned.

DEER LAKE - Mapping and sampling were conducted in this area in 1982. The 1984 work involved sampling and mapping within the boundaries of Deer Lake airport. Large deposits of sand with lesser amounts of gravel exist within the airport property, but they display the same poor petrographic characteristics as deposits outside the boundaries.

A potentially high-grade clay deposit was located and sampled at Nicholsville on the shore of Deer Lake. More detailed sampling will have to be completed to more accurately determine the extent and quality of this deposit and to evaluate its potential for brick or ceramic uses.

GRAND BANK/FORTUNE - High quality sand and gravel resources in the area are confined to a large glaciofluvial terrace deposit, a number of esker ridges at Fortune, and an esker ridge and small marine terrace at Grand Bank. Housing developments and private land ownership have sterilized or barred access to much of these resources.

Glacial tills in the area are composed of thin silty veneers over bedrock. Although petrographically sound, the high silt content restricts the use of till as a source of aggregate without substantial washing and screening.

Bedrock exposures are generally of volcanic origin, but there are exposures of shale at Fortune. Quarry potential in the volcanic rocks ranges from good to moderate. Presently, shale is being used as a source of fill materials in the Fortune area.

CONCEPTION BAY NORTH - High quality sand and gravel deposits are confined to the river valleys at Shearstown, North River, Springfield and Marysvale. Most of the deposits in these areas are under private land ownership. Virtually all of the deposit at North River is unrecoverable due to extensive housing development, and much of the land in the other areas is under agricultural development. A large quarry at Springfield supplies over 90% of the high quality aggregate used in the area. This area is privately owned and sections are leased out to various contractors. Petrographic analyses of samples show they are of excellent quality for most high-grade aggregate uses.

Glacial till deposits in the area are mostly thin, discontinuous, and poor quality due to a high silt content. However, some better quality tills that generally have good petrographic characteristics were mapped within the area

Bedrock in the area is mainly siltstone and sandstone, although volcanic rocks predominate in the southern part of the study area. Most of these rock types are suitable as aggregate sources.

FALL/WINTER PROGRAM, 1984/85

Preliminary maps showing the areas with the greatest aggregate potential, as identified from field investigations, are being forwarded to the Department of Municipal Affairs on a regular basis for inclusion into draft municipal plans.

During the late fall and winter of 1984-85, maps and sample analyses with accompanying reports will be compiled for open file release.

ACKNOWLEDGEMENTS

The author wishes to thank Paul LeGrow for his capable assistance in the field, Christine Blackwood for her work in the laboratory, and others who contributed to the project.

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REPORT OF THE GEOCHEMICAL LABORATORY FOR 1984

by

H.A. Wagenbauer
Geochemistry Section

The output for the laboratory for the past year is summaried in Table 1. The number of determinations increased by 25% over the previous year, and all work on samples from the 1983 field season was completed prior to August 1, 1984. The increase in output is due in part to the addition of three temporary laboratory assistant positions.

TABLE 1

Summary of the output from the geochemical laboratory of the Mineral Development Division from September 1, 1983 to August 31, 1984.

Geochemical Analyses of Soil, Till Lake and Stream Sediments:	Number of Determinations
Silicate Analyses:	
Trace Elements:	28179
Major Elements:	24363
Miscellaneous Analyses:	
Assays, F, Ba, Sr, H_2O^+, CO_2 and S on a variety of sample types.	8634
	109853
Sample Preparation:	**Number of Samples**
Rock Samples, Hammer Broken	237
Rock Samples, Crushed	2117
Rock Samples, Pulverized	2230
Lake, Stream and Soil Samples Sieved	3707
Miscellaneous:	
Sample Splitting, Uranium Weighing, Samples Shipped out for Analysis	17809

CORE STORAGE PROGRAM, 1984

by

A. Harris and S. Cochrane
Publications and Information Section

During 1979, the Newfoundland Department of Mines and Energy started a drill core collection and storage program. The objective is to provide well maintained and representative collections of drill core from as many drilling programs as possible for the future use of the mineral exploration industry, government geoscientists, university geoscientists and other geotechnical people.

DRILL CORE COLLECTION

During the 1984 field season, drill core collection continued in insular Newfoundland, and abandoned drill sites in western Labrador were inspected and core identified for collection in 1985. In insular Newfoundland, 7,566 m of core was collected from thirteen projects and in western Labrador 1,920 m of core from four projects was identified for collection in 1985. To date, the core storage program has collected 149,012 m of drill core, of which 121,099 m is classified as "open" and is available for inspection by interested persons. Figures 1 and 2 show the locations of all sites from which core has been collected and Tables 1 and 2 provide a list of the collected core.

The core storage program is presently storing 27,913 m of core from ten drilling projects on a confidential basis. Requests for confidential storage are treated individually. Conditions and terms of confidential storage are tied to land status and are similar to the terms and conditions of confidentiality which apply to assessment reports.

The Mineral Regulations regarding drill core read as shown in Appendix I. No changes to these Regulations are planned.

DRILL CORE LIBRARIES

The Department of Mines and Energy operates three drill core libraries, located in St. John's, Pasadena and Goose Bay.

The St. John's library is staffed on a full-time basis, except during the field season. It has a capacity of 60,000 m of drill core. Approximately 12,000 m of drill core has been catalogued and placed on the rack system to date. Most of this core is from eastern Newfoundland, from the St. Lawrence area and the "silica survey" drilling conducted by the provincial government during the 1960's. Drill core logs and location maps have been prepared for catalogued core. The St. John's library also contains rock cutting equipment, core splitters, a stereomicroscope, a magnetic susceptibility meter, a resistivity meter, an ultraviolet light and a McPhar TV-1 scintillometer. This facility and equipment is available for use on approved projects by exploration geologists, university researchers, the staff of the Department of Mines and Energy and other interested persons.

The Pasadena core library is also staffed on a full-time basis. This library has equipment and facilities similar to the St. John's library and has a capacity of 200,000 m of core. It has a ventilated room for storing radioactive core and a humidity-controlled room for storing salt core. There are approximately 121,000 m of core presently stored in the Pasadena library, collected from drilling sites west of Gander.

The Goose Bay core library, which contains core from Labrador, though not staffed full-time, has a capacity of 60,000 m of core, with room for expansion. Approximately 8,600 m of core have been catalogued and placed on the rack system to date.

PLANS

Plans include completion of cataloguing and indexing of all open core in the three libraries by mid-1985 and continuing collection programs, with emphasis on St. John's and Pasadena during the off-season. The production of drill hole location maps for all open core in the three libraries is scheduled for 1985. We encourage explorationists to use our facilities for core storage and related research. There is space available in all three libraries for confidential storage.

An index of all open core in the three libraries is available.

TABLE 1: SUMMARY OF CORE COLLECTED TO DATE - INSULAR NEWFOUNDLAND

No.	Company	Year	Property	# of Holes	Total Metres	Storage Location
1	Advocate	1967	Rambler	2	1,193.0	P
2	Amax	1976	Fischells Area	2	1,420.3	P
3	Amoco	1978	Burnt Pond	4	609.6	P
4	Beth Canada	1978	Springer's Hill	10	911.7	P
5	Boylen-Cerro		Colchester	18	1,379.2	P
6	Canadian Ref.	1970	Aguathuna	13	850.1	P
7	Chevron	1979	Eddies Cove	11	481.6	P
8	Cominco-Hansa	1973(?)	Bobby's Pond	5	431.6	P
9	Hooker Chemical	1968	Fischells	1	173.4	SJ
10	HBOG	1978	Gt. Rattling Bk.	11	818.6	P
11	HBOG	1978	Reid Lot 223	5	306.3	P
12	HBOG	1978	Reid Lot 225	2	117.0	P
13	HBOG	1978	Top Pond	1	47.1	P
14	Internat. Mogul	1974	Campbellton Area	15	1,394.5	P
15	Internat. Mogul	1975	Gander Area	12	708.7	P
16	Minorex	1978	Atlantic Lake	6	439.5	P
17	Nfld. Mines Br.		Port au Port	?	811.5	P
18	Noranda	1972	Point Leamington	3	265.8	P
19	Noranda	1973	Gullbridge	1	54.9	P
20	Noranda	1975	Leonard's Lake	3	388.6	P
21	Noranda	1975-78	Tally Pond	2	489.2	P
22	Noranda	1978	Burnt Pond	2	165.0	P
08	Noranda	1978	Bobby's Pond	4	320.6	P
23	Shell Can. Res.	1975-76	Main Brook Area	32	1,859.3	P
24	Texas Gulf	1975	Seal Bay	8	1,104.9	P
19	Gullbridge Mines	?	Gullbridge	213	12,473.9	P
25	Consol. Morr.	1976	Lake Bond	2	419.1	P
26	L.M. & E.	?	Lake Ambrose	6	647.7	SJ
27	Kerr Addison	1974-75	Victoria Area	5	655.3	P
28	Shawmont	1977-78	Hinds Brook	28	822.9	P
29	Advocate	?	Priests Showing	8	774.8	P
30	Advocate	?	Nippers Harbour	7	946.1	P
31	Advocate	1976	West Pond	3	144.7	P
32	Advocate	1975	Flatwater Pond	11	907.6	P
33	ALCAN	?	St. Lawrence	?	8,153.4	SJ
34	D.S. Robertson	?	Mt. Margaret Area	?	4,463.8	SJ
35	D.S. Robertson	?	Lawn Area	?		SJ
36	Noranda	?	Round Pond Area	?	?	P
37	RIOCANEX	1976	Cold Spring Pond	1	30.0	SJ
38	Falconbridge	1979	Strickland Property	?	4,427.2	P
39	Falconbridge	1981	Burgeo Road	16	1,059.2	P
40	Long Lac Min.	1968	Strickland Property	18	975.3	P
41	Minorex	1978-80	Deer Lake	25	1,993.3	P
42	U.S. Borax	1979	Hidden Pond	11	237.6	P
43	Nfld. Mines Branch	1960's	Fortune (Silica)	3	199.9	SJ
44	Nfld. Mines Branch	1960's	Long Harbour (Silica)	6	232.5	SJ
45	Nfld. Mines Branch	1960's	Argentia (Silica)	11	731.6	SJ
46	Nfld. Mines Branch	1960's	Thornlea (Silica)	6	230.9	SJ
47	Nfld. Mines Branch	1960's	Bellevue (Silica)	7	187.1	SJ
48	Nfld. Mines Branch	1960's	Long Cove (Silica)	4	164.1	SJ
49	Nfld. Mines Branch	1960's	Grey River (Silica)	6	256.2	SJ
50	Nfld. Mines Branch	1960's	Bonne Bay (Silica)	4	197.2	SJ
51	U.S. Borax	1981	Daniels Harbour	2	804.6	P
52	Minorex	1981	Silverdale	7	203.6	P
53	Minorex	1979-80	Deer Lake	?	109.7	P
54+	Westfield Minerals	1978-81	Deer Lake	130	8,314.9	P
55+	Northgate Expl.	1979	Deer Lake	16	2,511.5	P
56	RIOCANEX	1978-81	Cape Ray	171	20,461.0	P
57	Essex	1981	Watts Bight	4	609.6	P
58	Shell Can. Res.	1980	Codroy Valley	6	890.0	P
59+	Flintkote	1979-80	Flat Bay	?	3,214.0	P
60+	Newmont	1981	Tilt Cove	6	864.1	P
61+	Rambler Mines	?	Ming Mine	64	19,150.0	P

TABLE 1: (Cont'd)

No.	Company	Year	Property	# of Holes	Total Metres	Storage Location
62	BRINEX	?	Whalesback	235	12,226.0	P
63	RIOCANEX	1976	Great Burnt Lake	9	1,463.0	P
64	St. Joe Can.	1982	Big Pond	9	707.0	P
65	Billiton	1981	Ghost Pond	3	668.0	P
66+	Esso Minerals	1982	Ackley Granite	5	280.0	SJ
67	HBOG	1980	Gander Lake South	7	296.1	P
68	HBOG	1980	New Bay Pond	6	356.8	P
69	NAREX ORE SEARCH	1983	Round Pond	21	402.3	P
70	U.S. Borax	1983	Handcamp	7	683.8	P
71	Falconbridge	1979	Handcamp	9	730.6	P
72	Eldorado Nuclear	1979	Portland Creek	1	113.1	P
73	Westfield Minerals	1978	Wigwam Brook	12	576.0	P
74	Dupont Canada Expl.	1983	Gullbridge	2	312.0	P
75	Nfld. Mines Branch	1983	Robinson's River	1	343.2	P
76-80	Confidential Storage	1983-4	Southwest Nfld.	34	4,405.0	P
				Total	138,769.3	

Key

P - Pasadena Core Library
SJ - St. John's Core Library
+ - Temporary Confidential Storage

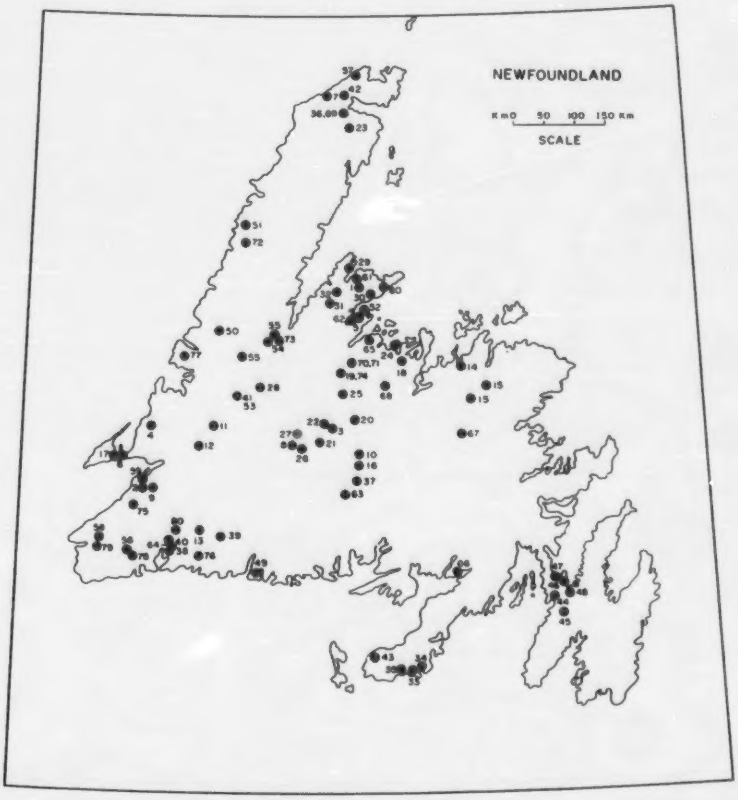

Figure 1: *Core collection sites, insular Newfoundland*

TABLE 2: SUMMARY OF CORE COLLECTED TO DATE - LABRADOR

No.	Company	Year	Property	# of Holes	Total Metres	Storage Location
1	American Metal Co.	1954	Green Pond	3	16.7	GB
2	BRINEX	1972	Seal Lake	19	1,333.5	GB
3	Canadian Nickel Co.	1978-80	Moran Lake	30	2,103.1	GB
4	Mokta Can. Ltd.	1965	Moran Lake	8	220.9	GB
5	Northgate Explor. Ltd.	1980	Lake Melville	8	652.2	GB
6	Placer Devel. Ltd.	1980-81	Banana Lake	11	655.3	GB
7	RIOCANEX	1961	Ten Mile Lake	4	197.5	P
8	Shell Can. Res.	1977-79	Moran Lake	61	3,822.2	GB
9	Shell Can. Res.	1977	Sylvia Lake	3	99.4	GB
10	Shell Can. Res.	1977	Madsen Lake	2	114.8	GB
11	Nfld. and Lab. Hydro	?	Gull Island		1,037.8	GB
					Total 10,253.4 m	

Key

GB - Goose Bay Library
P - Pasadena Library

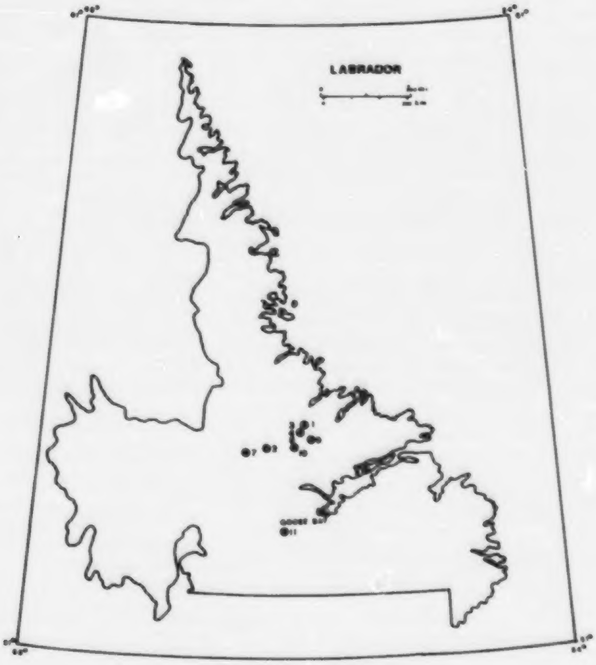

Figure 2: *Core collection sites, Labrador*

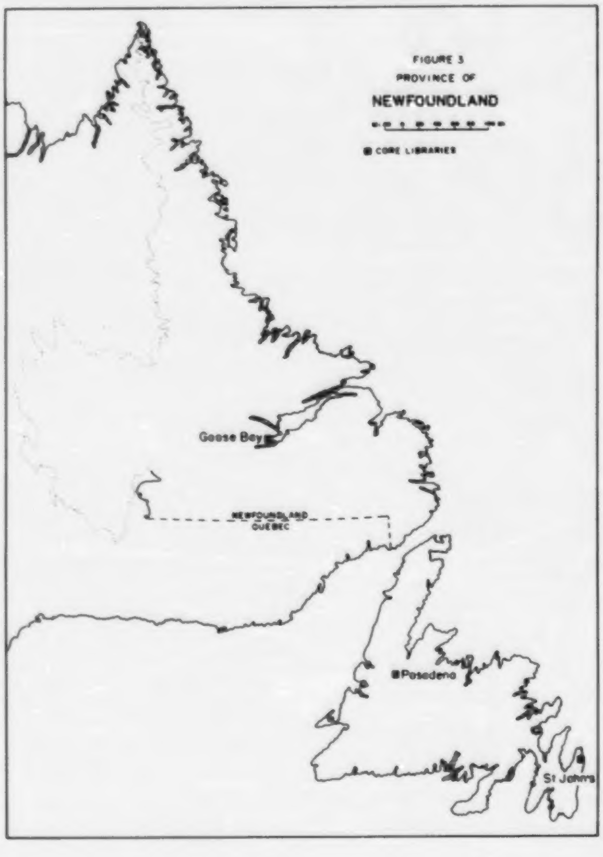

Figure 3: *Core libraries in the province of Newfoundland and Labrador*

APPENDIX I

MINERAL REGULATIONS RE: DRILL CORE

Preservation of diamond drill core

64. No person, whether a holder of mineral rights issued under this Act or these Regulations or not, shall intentionally abandon, discard, dump, destroy or otherwise reduce the original technical value of any diamond drill core or rotary drill cuttings obtained for information purposes within the Province or remove same from the Province, except for those sections submitted for assaying, testing, microscopic, metallurgical and beneficiation studies, without the permission of the Minister.

Minister may allow disposal or obtain core for Crown

65.(1) All persons proposing to dispose of any diamond drill core in their possession or lodged with them for safekeeping, shall notify the Minister of their desire to do so and upon receipt of such notification the Minister

(a) shall provide such persons with permission in accordance with regulation 64 or

(b) may direct his authorized representative to take possession of such drill core for the Crown and take such other action as he may deem necessary.

(2) The actions directed by the Minister under paragraph (1) shall be undertaken at the expense of the Crown.

MINERAL ASSESSMENT REPORT LIBRARY MICROFICHE PROJECT

by

N.L. Mercer
Publications and Information Section

The Mineral Development Division maintains a geological and mineral resource assessment file system which is referred to as the "Mineral Assessment Report Library". This library presently consists of approximately 9,000 geological and geochemical reports, maps, journal articles and mineral assessment files, making them the largest and most comprehensive single collection of geoscience documents about Newfoundland and Labrador.

As a result of the high level of mineral exploration activity experienced during the late 1970's and early 1980's throughout the province, the amount of new data submitted increased substantially. New information is now available on many of the old and also numerous new mineral occurrences in the province. Much more is now known about the geology and mineral potential of various regions both on the island and in Labrador.

The Mineral Development Division has also conducted a large number of field projects over the past few years. This has resulted in the publication of many new geological reports, maps and open files as well as the results of numerous geochemical surveys and surficial and aggregate resource studies.

Mining and exploration companies, prospectors, geotechnical and consultant firms, government agencies, universities, libraries and the general public are continually making use of the geofiles and requesting information from them. Requests have increased substantially in the past few years.

During the past five years the Publications and Information Section has been putting all of the good quality mineral assessment reports on microfiche. This provides a much more efficient system of maintaining the geofiles. Requests for information are processed more rapidly and easily, with relatively inexpensive charges for microfiche.

The microfiche project involves daily filming of batches of reports. The reports are cross-checked before filming for quality, content and reproducibility. Two microfiche originals are made and cataloged for each file. Filing follows the standards of the National Topographic System. Duplicates can be copied from the original fiche upon demand. One set of fiche originals is stored offsite at the Torbay Core Library for security and protection from fire.

Microfiche sets of mineral assessment reports covering all 1:250,000 N.T.S. blocks in insular Newfoundland are available along with microfiche sets for many of the Newfoundland General Series reports. Several releases have also been made for microfiche sets of mineral assessment reports from a number of the 1:250,000 N.T.S. blocks in Labrador.

Work on the Labrador mineral assessment reports is continuing and we are expecting to make several more releases of duplicate sets of microfiche by Christmas. Labrador has been the focus of our attention this year and we are expecting to complete this phase of the project in 1985.

The total cost of mineral assessment reports which are available as microfiche duplicates is $1,757.00

During 1984, we also continued placing the mineral occurrence reports on microfiche and making them available. Presently, mineral occurrence reports for N.T.S. 2E, 12B and 12P in Newfoundland, and N.T.S. 13K, 13N and 14C in Labrador are available. Further releases will be made as staff in the Mineral Deposits Section complete new N.T.S. areas.

For information, please contact Norman Mercer (709) 737-3159. We look forward to your comments and suggestions.

ACKNOWLEDGEMENTS

Doreen Mahon is thanked for her excellent work on the microfiche project this past year.

The Department of Mines and Energy also acknowledges the continued participation and cooperation of Ches Hapgood and staff of the Micrographics Section, Newfoundland Department of Public Works and Services, especially in filming and duplicating the geofiles.

GEOSCAN - THE NATIONAL DATABASE FOR GEOLOGICAL INFORMATION: THE NEWFOUNDLAND CONTRIBUTION

by

Catherine Patey
Publications and Information Section

GEOSCAN is a computerized bibliographic database of Canadian-produced and/or Canada-related geoscience documents.

The Newfoundland Department of Mines and Energy is one of the ten agencies which index documents for input into this database. Our Mineral Assessment Report Library files and mineral inventory cards are the sources of our indexed documents. Other agencies, e.g. the Geological Survey of Canada and the Earth Physics Branch of the Canada Department of Energy, Mines and Resources, also produce and index documents that concern this province.

In 1982, the National GEOSCAN Center, which manages GEOSCAN, implemented a new software system, called MINISIS, to input and retrieve the bibliographic data more effectively. In the implementation of the new system, all the old documents were converted to a new format. For example, different types of keywords were moved into different fields: map types, illustrations, geological terms. Although most of the records did convert, they did not convert cleanly and completely. For example, reports may be missing a title or authors and terms may have been assigned to the wrong fields. In cooperation with the National GEOSCAN Center, these old documents are being corrected.

All new documents are input directly onto the new system and are immediately retrievable online. To date, only indexed documents from assessment files have been keyed into the system, although other types of documents, in particular government publications, have been coded.

Besides indexing and keying new documents, new coding sheets are being produced, the authority files or thesauri used in coding are being enlarged, and the terms used are being more clearly defined.

All of the 87,000 GEOSCAN records from across Canada, including those concerning this province, are available through online computer searches at the Geological Survey of Canada Library in Ottawa and, in St. John's, at our Publications and Information Section. Searches are performed on a cost-recovery basis with a minimal charge of $10.00 per search topic. A moderate size search (100-200 titles) costs between $15 and $45.

As well, GEOSCAN Newfoundland and Labrador indexes current to February 1982, the date of the last update on the old system, are available from the Publications and Information Section. A computer printout sorted by National Topographic System area is also available for the newer documents.

We welcome suggestions for improvements and appreciate being notified of any errors or discrepancies that you may discover in the earlier indexes. This will aid us in making detailed modifications of the documents.

For further information on GEOSCAN, please contact Catherine Patey (709) 737-3159.

MINERAL OCCURRENCE DATA SYSTEM

by

C.F O'Driscoll
Mineral Deposits Section

INTRODUCTION

The Mineral Occurrence Data System is designed to offer an efficient information service on all mineral occurrences in Newfoundland and Labrador. It is a two-part project comprising a Mineral Inventory File and a computerized Mineral Index.

MINERAL INVENTORY FILE

The Mineral Inventory File consists of mineral occurrence descriptions which summarize all the available information on known mineral occurrences in the province. A description may be prepared for any type of occurrence from an indication to a producing mine. It contains information under the following headings: name, product, owner/operator, land tenure, location and access, description, history of exploration and development, production and/or reserves, status, type of deposit, mineralogical composition, nature of mineralization and genesis, host rocks, structure of deposit, structural features and tectonic setting, metal/mineral content, geophysical expression, geochemical expression, physiographic setting, remarks and references.

Information on all mineral occurrences for the island of Newfoundland has been compiled except area 11P (see Figure 1). Areas 1L and 1M are now being input and will be available within the next few months. Areas which have been completed in Labrador are: 13I, 13J, 13K, 13N, 13O, 14C, 23I, 23J and 23O (see Figure 2). These map areas are located in the Central Mineral Belt and the Labrador Trough.

At present, the file consists of approximately 3000 mineral occurrence descriptions and each description contains at least 3 pages and in some cases up to 10 pages. The whole file contains approximately 15,000 pages. These descriptions are available at the cost of 15 cents per sheet.

The file is presently being microfiched with topographic location maps and as they are completed, copies will be available upon request. Areas which have been microfiched are 2C, 2E, 2F, 12B, 12H, 12P, 13K, 13N and 14C. It is hoped to have the complete file microfiched over the next year.

1:250,000 mineral occurrence maps with updated geological bases are being prepared for printing. So far, twelve maps have been printed and are available upon request at a cost of $3.00 each. These are 2C, 2D, 2E, 2F, 2M, 11O, 12B, 12G, 12P, 13K, 13N and 14C. In addition, a 1:100,000 map of parts of 13J and O and a 1:50,000 map of 13K/5 are printed and available. These maps contain locations of all mineral occurrences in the area together with a listing of these occurrences which includes the name, status and minerals present. Published maps for most of Newfoundland and some parts of Labrador will be available within the next year.

COMPUTERIZED MINERAL INDEX

The computerized Mineral Index contains information selectively extracted from the Mineral Inventory File. When complete, it will be possible to make a wide variety of complex retrievals which would be virtually impossible if a manual system were used. The computerized file is not presently available for reproduction but can be accessed at the Department of Mines and Energy offices in St. John's.

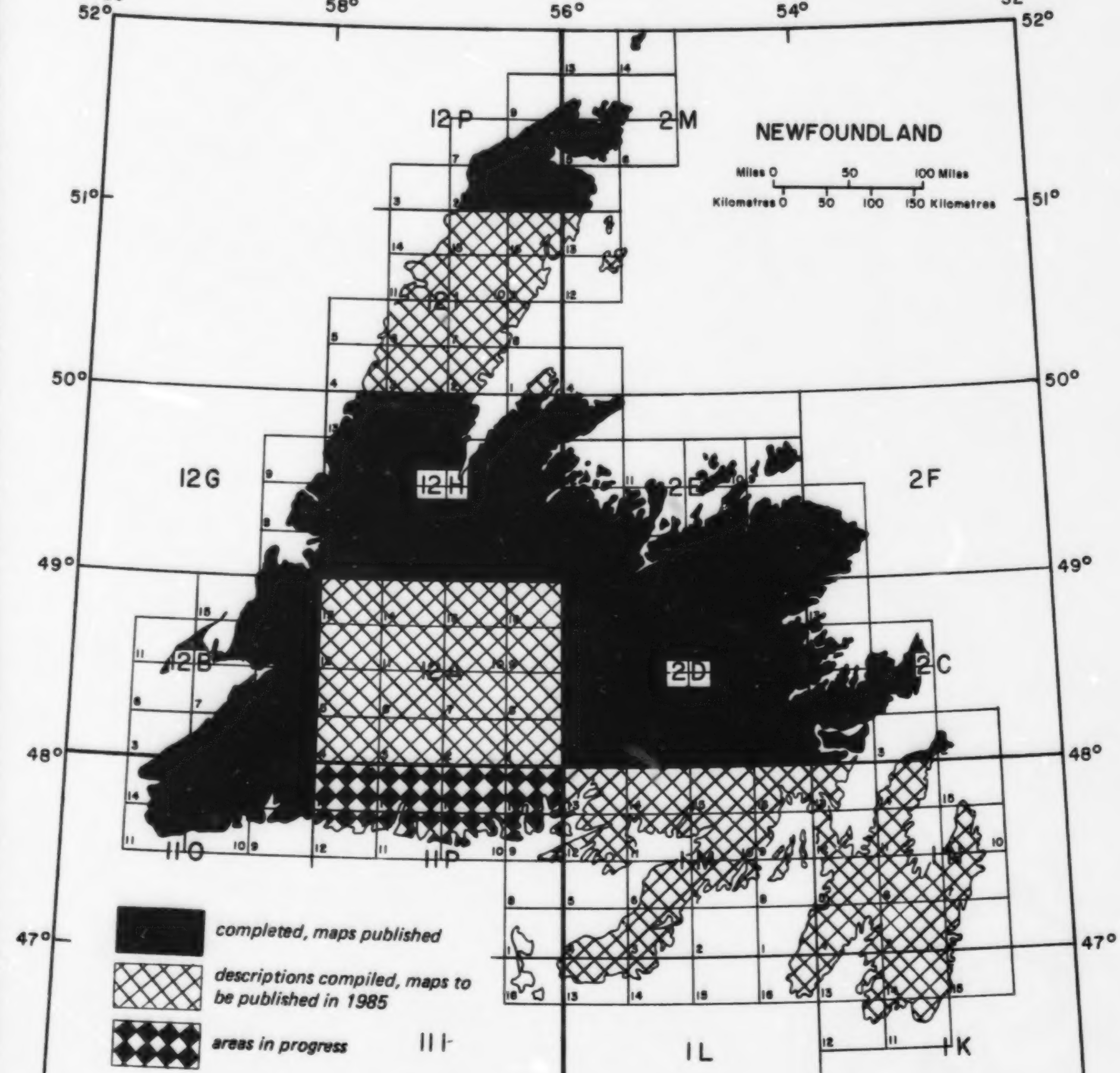

FIGURE 1: *Index map for Mineral Occurrence Data System project, insular Newfoundland.*

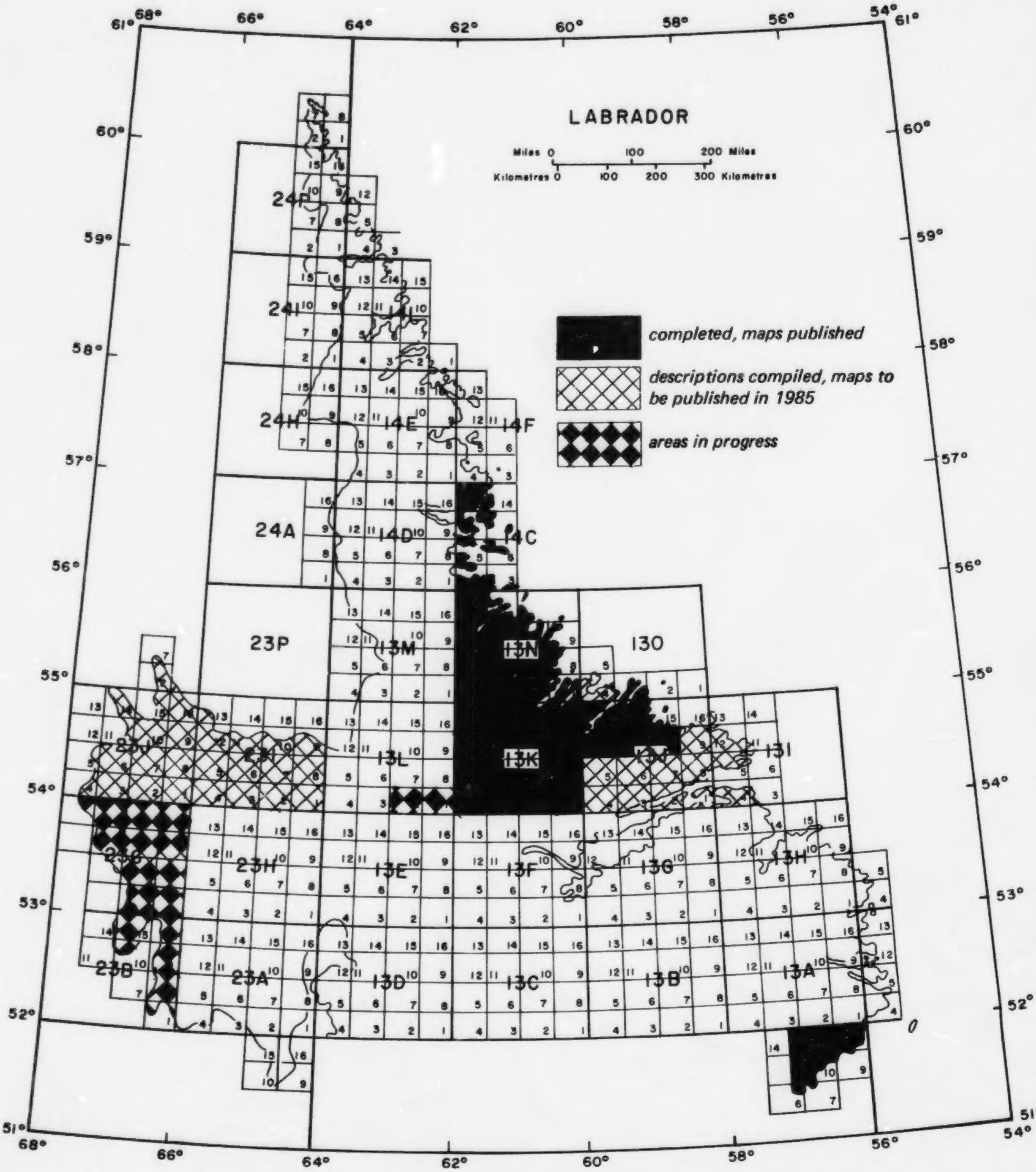

FIGURE 2: *Index map for Mineral Occurrence Data System project, Labrador.*

COMPUTER UNIT

by

Harjit Missan
Geochemistry-Geophysics Section

The Computer Unit is responsible for maintaining and archiving geological databases that have been created as a result of projects carried out by the staff of the Mineral Development Division. In addition, the Computer Unit is developing programs for use by geologists for analyzing data.

HARDWARE SUPPORT

The mainframe computer used to meet the needs of the Division is the AMDAHL 5860 at Higgins Line (NLCS), which is accessed through three high speed terminals. In addition, two microcomputers, a Tektronix 4054 Graphic System and a Texas Instrument Professional Computer are used for analyzing small to medium sized databases.

SOFTWARE SUPPORT

a) Mainframe (Amdahl 5860)

For large databases that are maintained on the mainframe, the following software systems are used:

i) SPSS-X and SAS - used mostly for geochemical and lithogeochemical databases
ii) GRASP - used for the Mineral Occurrence Data System (MODS)
iii) SIR - used for the Aggregate Resource Databank

b) Microcomputers (Tektronix and Texas Instrument PC)

The microcomputers are used essentially for small to medium sized databases that have been downloaded from the mainframe. The most widely used programs are MICRO-GRASP and CIPW.

STAFF SUPPORT

The Computer Unit comprises three people: the Unit Head and two programmers. One of the responsibilities of the staff is to help geologists computerize their data and train them in the use of computers for data analysis.

USES OF THE COMPUTER SYSTEMS

Over the past year, extensive work has been done on the various geological, geochemical, mineral deposit and aggregate resource databanks that are being developed. The mainframe computer has been used to produce reports and map plots, e.g. location of sample points, spatial distribution of various chemical elements. In addition, a program called SURFACE II was used to display geochemical data in contoured form and in three dimensional perspective, thus enhancing the characteristics of the data.

Because of the ease of use of the program MICRO-GRASP, the microcomputers were used very extensively by geologists. The system was used for data analysis and for displaying data in graphical form, e.g. Ternary diagrams and Harker variation diagrams were plotted as aids in the interpretation of the data.

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This project is a contribution to the Canada-Newfoundland Mineral Development Agreement.

FLUORINE ANALYSES OF DRINKING WATER IN NEWFOUNDLAND AND LABRADOR

by

Rex Gibbons, Geoffrey Dawe and Hank Wagenbauer

Most people would be happier with less tooth decay and fewer fillings. People have less tooth decay if their drinking water contains fluoride because, as teeth form during childhood, the fluoride becomes part of the tooth enamel, making teeth stronger and more resistant to decay.

A booklet "Facts Favour Fluoridation", published by the Canadian Dental Association, reviews the facts and some of the myths about fluoridation. The following information is based on this booklet.

In 1978, the federal Department of National Health and Welfare reviewed medical evidence, including three recent studies on cancer, and concluded that "the maintenance of the fluoride level in drinking water at approximately 1 mg/L (1 milligram to the litre or 1 part per million) is the most efficient procedure to decrease the incidence of dental caries (tooth decay), and such a level of fluoride poses no risk to the health of Canadians".

Most natural water contains some fluoride. Since 1917, Stratford, Ontario has used naturally fluoridated water containing 1.3 to 1.6 mg/L of fluoride. The average 16-18 year old in Stratford has only four permanent teeth showing any sign of tooth decay. However, in cities with little or no fluoride in the water supply, the average 16-18 year old has more than 10 decayed teeth.

More than 10 million Canadians and Americans have consumed water with 0.7 to 2 mg/L naturally occurring fluoride for most or all of their lives. In hundreds of communities using artificial fluoridation, the amount of tooth decay in children has been reduced to the same low levels found in communities with naturally fluoridated water.

The Association states that "fluoridation, coupled with regular tooth-brushing and less sweet food, is the most practical and economical way to prevent dental problems" and "will reduce tooth decay by at least 50 per cent throughout life".

In 1983, Dr. Barton Manning, a dentist with a practice at Lumsden, Notre Dame Bay, and a keen interest in preventative dentistry, suggested to R. Gibbons that it would be interesting to analyze drinking waters throughout Newfoundland to determine which towns had naturally fluoridated supplies, and how this correlated with the geology and rock types of the different regions.

During the Fall, 1983, fifty samples were collected throughout the province. Manning provided samples from Fogo Island. The other samples were collected by staff of the provincial Department of Mines and Energy while travelling throughout the province on other field projects. The samples were analyzed by G. Dawe at the Mineral Development Division laboratory in St. John's, under the direction of H. Wagenbauer.

The analyses are given in the accompanying table. The only water supplies with fluorine near the recommended level are Gander, Corner Brook and Goose Bay, and these three are the only towns in Newfoundland and Labrador with artificially fluoridated water. All other water analyzed from towns with central supplies ranged from less than 0.01 mg/L (e.g. Lumsden) to about 0.05 mg/L, which is negligible in all cases. A few cases where water was still being obtained from wells had slightly higher values, including Gambo, Little St. Lawrence, and the Fogo Hospital; these values are almost half the recommended optimum level, and reflect water sources in deeper groundwater as well as the effects of associated rocks and aggregates. The central surface water supplies from ponds show no significant fluorine addition from associated rocks.

After doing these analyses, we became aware of a study done by Harris and others (1973) at Memorial University on "Environment and Health in Newfoundland". In that study, water was analyzed from 33 towns in Newfoundland; only six duplicated those sampled by us in 1983. However, the results were comparable; most samples analyzed in the range of 0.01 to 0.05 mg/L, including St. John's at 0.03 mg/L. The exceptions included Fogo Central High School at 2.10 mg/L and some other artesian wells on Fogo Island, particularly at Barr'd Island, Joe Batt's Arm and Fogo. The only other analyses above 1 mg/L were in Joe Batt's Arm, where the well at the fish plant analyzed at 4.0 mg/L and one at the bus stop analyzed at 3.5 mg/L. These values for Fogo Island can be correlated with a fluorine-rich granite on the northern part of the island.

The analyses from both studies indicate that natural fluoridation near the optimum level of 1 mg/L is rare in Newfoundland and Labrador. Except for parts of

Fluorine Analyses of Drinking Water in Newfoundland and Labrador

LAB. NO.	SITE	mg/L F⁻
1	Gambo (Well)	0.34
2	Centreville	0.03
3	Wesleyville	0.02
4	Hare Bay	0.03
5	Newtown	0.02
6	Lumsden	<0.01
7	Valleyfield	0.02
8	Cape Freels (Well)	0.03
9	Indian Bay (Parsons Point)	0.02
10	Whitbourne	0.06
11	Trinity, Bonavista Bay	0.02
12	Lewisporte	0.02
13	Gander (Airport)*	0.89*
14	Grand Falls	0.04
15	Goose Bay, Labrador*	1.13*
16	Stephenville (College)	0.03
17	Glenwood	0.02
18	Norris Arm South	0.01
19	Bishops Falls	0.02
20	Corner Brook*	0.67*
21	Ming's Bight	0.01
22	L. Moores/Stephenville	0.03
23	L. Howse/Kippens (Well)	0.09
24	Pasadena	0.02
25	Woodstock (y)	0.04
26	Springdale	0.02
27	Baie Verte (sl.y)	0.01
28	Deer Lake	0.03
29	Hawkes Bay	0.04
30	Pacquet (y)	0.04
31	Parsons Pond	0.04
32	Port Saunders	0.02
33	St. Pauls	0.02
34	Cow Head	0.01
35	Daniel's Harbour	0.05
36	Rocky Harbour	0.03
37	St. Lawrence (School)	0.07
38	Lamaline (School)	0.03
39	Grand Bank	0.02
40	Little St. Lawrence (Well)	0.41
41	St. Bernards (Well)	0.19
42	Burin (R.C.M.P. Station)	0.01
43	Swift Current	0.09
44	Fortune	0.05
45	Marystown	0.01
46	Lawn	0.05
47	Cole's Well (Fogo) (y)	0.15
48	Payne's Well (Fogo) (y)	0.07
49	Hospital (Fogo)	0.41
50	Cole's Spring (Fogo) (sl.y)	0.02

y - yellow
sl.y - slightly yellow

* Gander, Corner Brook and Goose Bay have artificial fluoridation of their water.

Fogo Island where water is obtained from artesian wells in fluorine-rich granite, and where some of this water reaches higher fluorine content than is recommended, most of the drinking water supplies are deficient in natural fluorine. To date, only three towns, Gander, Corner Brook and Goose Bay, use artificial fluoridation to bring their water near the 1 mg/L level.

In December, 1984, a 2-year project was announced to study children's dental health in Newfoundland and Labrador under the sponsorship of the Hospital for Sick Children Foundation at a cost of about $26,000. This is to be done under the direction of Dr. Sharat Doshi of the Newfoundland Department of Health in collaboration with a number of other medical specialists. The study is to be carried out in rural Newfoundland with about 500 children, and is supplementary to a still unpublished study conducted in 1982 on 350 children from larger communities on the island by Dr. David Banting of the University of Western Ontario.

Based on the water analyses from this project and Harris and others (1973), the dental study should include children from Gander, Corner Brook, Goose Bay and Fogo Island, as well as a selection of the sites with negligible fluorine in their water supplies; St. John's should be included with the latter. Geologically, it appears that no sites in the province reach the recommended optimum levels from natural fluoridation, and artificial fluoridation is the only answer for any town that wishes to use fluoridation as a means of preventative dentistry.

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